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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

APRIL 1920

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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. VI April, 1920 No. 4

The Summer Meeting at Ottawa Beach

THE Summer Meeting of the Society at Ottawa Beach, Mich., commences Monday, June 21. The Standards Committee will meet to transact important business at 10 a.m. It is expected that most members of the divisions will be in attendance and that many decisions will be reached by the committee at this meeting. The program of the Standards Committee meeting will be sent to all of the members of the committee well in advance of the meeting.

There will be an excellent opportunity for members attending on Monday to take part in the several contests and tournaments scheduled for the first day. These events including baseball, tennis and golf, will start about 3 p.m., thus interfering least with the business of the day. The business session of the society will be held in the evening.

Accommodations and Rates

Returns from announcements sent out indicate the extensive interest of members in the meeting. Accommodations at Ottawa Beach will probably be taxed but arrangements have been made so that every member desiring to attend will have comfortable quarters. Descriptive bulletins showing the capacity of Hotel Ottawa and Waukazoo Inn and containing useful instructions for making requests for hotel accommodations, have been sent to the members. Early applications will greatly facilitate the work of the Meetings Committee in making hotel assignments. As was the case last year, married couples will be assigned to comfortable rooms in the annex of Hotel Ottawa and at the Waukazoo Inn. Many improvements are being made at both hotels in the matter of baths. Incidentally, assurances are at hand relative to the golf ground improvements.

The rates are not greatly increased over those of last year. This is remarkable in view of the increased program planned for this meeting in sports, exhibits and entertainments.

Members are taking advantage in increasing numbers each year of the Summer Meeting program of technical papers, recreational features and low accommodation rates, to make the Summer Meeting a week of vacation for themselves and their families.

Sports and Recreation

The program of sports will include besides the events listed below, many novel amateur games which have recently been evolved by one of America's foremost playground directors. These new games together with the afternoon sports and competitions provide a splendid opportunity for all to join in a great variety of sporting events. The schedule of contests is as follows:

Baseball, S. A. E. championship
Golf tournament for men
Golf tournament for ladies
Tennis doubles for men
Tennis doubles, mixed
Tennis singles for men
Tennis singles for ladies
Trap shooting for men
Quoit tournament for men
Clock golf tournament for ladies and men
Five-hundred party for ladies
Bridge party for ladies
Throwing the baseball
Obstacle race, partly in the water
Canoe race for men
Driving the golf ball for men
Driving the golf ball for women
Shot put
Canoe tilting contest for men
Fat men's race (200 lb. minimum)
Stout ladies race (175 lb. minimum)
50-yd. dash for men under 28 years
50-yd. dash for men 28 to 35 years.
50-yd. dash for men over 35 years
50-yd. dash for ladies under 25 years
40-yd. dash for ladies over 25 years
Sand hill race for men
Sand hill race for ladies
Hop, skip and jump for men under 30 years
Hop, skip and jump for men over 30 years
Standing broad jump for men under 30 years
Standing broad jump for men over 30 years
Running broad jump for men under 30 years
Running broad jump for men over 30 years
High jump for men under 30 years
High jump for men over 30 years
Pole vault
Fishing contest (prize for largest bass caught)
Potato race for men
Potato race for ladies
Three-legged race for men
Egg race for women
Costume parade for men
Costume parade for women
Costume parade for children
Dancing contest, senior
Dancing contest, junior
Bait casting
Fly casting
Tug of war
Croquet doubles for ladies
Croquet singles for ladies

The fuller participation of members in the sports program is encouraged by the award of not more than one prize to a person. All entries should be made well in advance of the meeting by returning an entry blank to the Society's office, 29 West Thirty-ninth Street, New York City. Some of the contests have been arranged according to age classification. In the golf, clock golf and tennis tournaments, first, second and third prizes, will be awarded. In all, 100 or more prizes for sporting

events will be given to winners. The dancing competition carries to the winning lady free hotel accommodations at the 1921 Summer Meeting. Section stunts will occupy one-half hour after dinner each evening preceding the one-hour lecture. Following the lecture on Tuesday and Wednesday evenings dancing contests for seniors and juniors will be held. The grand ball on Thursday evening will be followed by a supper to which all members and guests are invited. The costume parade will be held during one afternoon of the meeting.

Professional Sessions

The important subject of better utilization of present fuels will be considered from many angles at the Fuel Session on Tuesday, June 22. All of the latest fuel developments will be discussed and papers of great interest are expected from men prominent in fuel research. On Wednesday morning, June 23, there will be a Transportation Session. So many of the members of the Society are interested in some form of transportation, equipment, aircraft, river or motor vehicle, that the transportation session should prove most attractive. Papers from well-known authorities will be presented. The Farm Power Session is jointly of interest to the agricultural and the automotive engineer. Valuable suggestions relative to this session are being received from able engineers in many sections of the country. At the Production Session on Friday, June 25, consideration will be given to papers dealing with the following phases of production:

(1) Material, an Element in Production
(2) Equipment, an Element in Production, including both Machine and Cutting Tools
(3) Steady Sales Demand and Production
(4) The Workman, a Factor in Production
(5) Production as a Factor in the Solution of the Present World Problem.

RESULT OF LETTER BALLOT ON STANDARDS

At the Annual Meeting of the Society held Jan. 7, forty-eight recommendations of fourteen Divisions of the Standards Committee were approved for final presentation to the voting members of the Society. These were adopted in their entirety by the letter ballot, which closed on March 22. The reports on which this action was taken were printed in The Journal in the January issue, on pages 4, 5 and 6 and 57 to 75 inclusive.

The complete vote on the recommendations is given below. The first column gives the number of affirmative votes cast; the second, the negative votes, and the third the number of members who did not vote either way.

BALL AND ROLLER BEARINGS DIVISION			
Annular Ball Bearings, Separable Type	172	1	141
Annular Ball Bearings, Extra Small Type	169	0	145
Corner Radii Tolerances	175	2	137
Annular Ball Bearings, Extra Large Type, Light Series	165	0	149
Annular Ball Bearings, Extra Large Type, Medium Series	165	0	149
Annular Ball Bearings, Extra Wide Type	168	0	146
ELECTRICAL EQUIPMENT DIVISION			
Bracket Mounting for Generators	185	0	129
Flange Mountings for Generators	183	1	130
ENGINE DIVISION			
Engine Support Arms	163	4	147
Tractor Flywheel Housings	151	1	162
Crankshaft Grinding Wheels	158	0	156
Engine Testing Forms	179	0	135
IRON AND STEEL DIVISION			
Tungsten Steel	169	0	145
Nickel Steel	174	3	137
Malleable Iron Castings	181	2	131
High-Chromium Steel (General Information only)	167	3	144
LIGHTING DIVISION			
Side-Lamp Glasses	155	1	158
Head-Lamp Illumination	150	1	163
MISCELLANEOUS DIVISION			
Oilless Bushings	164	6	144
Ball and Socket Joints	168	1	145
Fuel Vacuum-Tank Mounting and Connections	158	1	155
Tank and Radiator Caps	170	0	144
MOTORCYCLE DIVISION			
Spark-Plug Shells	118	3	193
NON-FERROUS METALS DIVISION			
Aluminum Alloy, Specification No. 30	154	0	160
Aluminum Alloy, Specification No. 31	151	1	162
Aluminum Alloy, Specification No. 32	152	1	161
MARINE DIVISION			
Reverse Couplings, Steel	90	0	224
Water-Pipe Flanges	97	1	216
Motorboat Control Levers	95	0	219
SHAFT FITTINGS DIVISION			
Four-Spline Fittings	168	2	144
Six-Spline Fittings	168	2	144
Ten-Spline Fittings	165	2	147
Sixteen-Spline Fittings	164	3	147
STATIONARY ENGINE AND LIGHTING PLANT DIVISION			
Approval of Existing S. A. E. Standards	137	0	177
Voltage and Capacity Ratings, Isolated Electric Lighting Plants	111	4	199
Cast-Iron Carbureter Flanges	120	3	191
TIRE AND RIM DIVISION			
Pneumatic Tires for Passenger Cars and Commercial Vehicles	154	1	159
Pneumatic Tires for Motorcycles	120	0	194
Solid Tire Sizes	137	1	176
Rim Sections and Contours for Pneumatic Tires (Correction)	148	0	166
Rim Sections and Contours for Pneumatic Tires (Extension)	147	1	166
Solid Tire Sections	134	0	180
Bolt Equipment for Solid Tire Side Flanges	134	0	180
Wood Spoke Dimensions for Commercial Vehicle Wheels	134	0	180
TRACTOR DIVISION			
Tractor Belt Speeds	123	1	190
Tractor Belt and Pulley Widths	122	2	190
TRUCK DIVISION			
Four-Wheel Trailer Hitches	114	1	199
Approval of Existing Standards	142	0	172

Ballots mailed, 2415
Valid ballots counted, 314
Unsigned ballots received, 4
Number of subjects adopted, 48
Number of subjects rejected, 0

Factors Involved in High Airplane Speed at Great Altitudes

By COMMANDER H. C. RICHARDSON,[1] U. S. N. (*Non-Member*)

PENNSYLVANIA SECTION PAPER *Illustrated with* CHARTS

THE development of the supercharger for aircraft engines has led to the possibility of hitherto unheard-of speed of transportation. Many predictions are extravagant, at least for the present state of the art, so it is attempted in the following analysis of a definite case to present the different aspects of the problem in practical form, with a view to determining what can reasonably be expected. The attempt is also made to arrive at a knowledge of those elements involved whose improvement will effect the greatest gain.

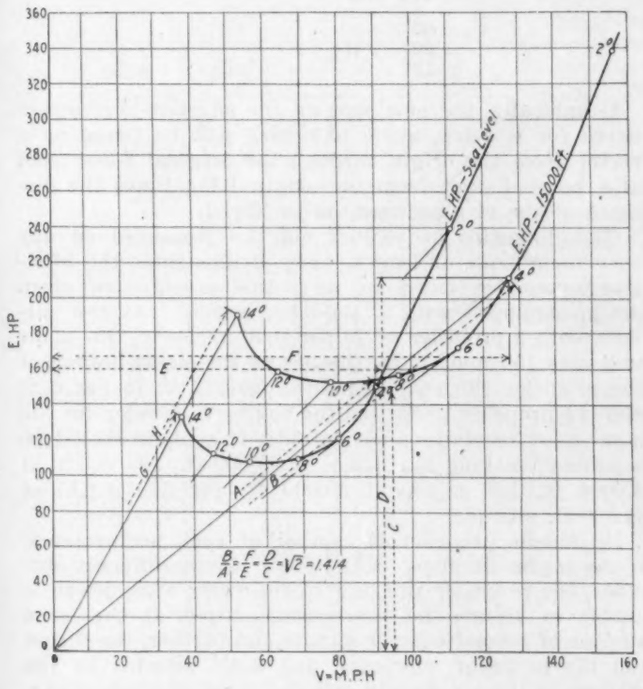

FIG. 1

As is well known, the ordinary gas engine suffers a serious loss of power at great altitudes, due to its inability to obtain sufficient oxygen for the combustion of a normal charge of gas which, in an engine of conventional design, is essential to the development of its maximum output. The supercharger overcomes this deficiency by providing a fuel mixture of normal proportions and density, practically eliminating the loss of power otherwise resulting from the rarefied atmosphere at great altitudes. To introduce exact corrections of the power available at different altitudes would require the introduction of data and refinements which are not essential to this investigation. It is therefore assumed that the supercharger is already in practical form and can be applied so as to furnish the same power output, unaffected at attainable altitudes. This requires also that the reduction of the heat-dispelling capacity of the radiating system is partly compensated by the low temperatures at great altitudes and partly by its excess capacity over that usually provided at sea level. Granting this, we may then assume as a first premise that the brake-horsepower characteristics based upon the performance at sea level can be accepted for this investigation as applying at great altitudes. This premise is substantially correct, and is essential for the following application to the problem.

[1]Chief engineer, Naval Aircraft Factory, League Island Navy Yard, Philadelphia, Pa.

REQUIRED AND AVAILABLE HORSEPOWER

Let us now consider the airplane itself. We have first to determine the horsepower required, and the influence of air density upon this factor; second, we must determine the horsepower available. This latter depends primarily upon the brake-horsepower characteristics of the engine employed, and secondarily upon the means of applying the engine power to propulsion, that is, to the propellers. Propulsion is the most interesting and important factor, as will be seen later.

The influence of altitude and air density upon the horsepower required is readily determined by a brief

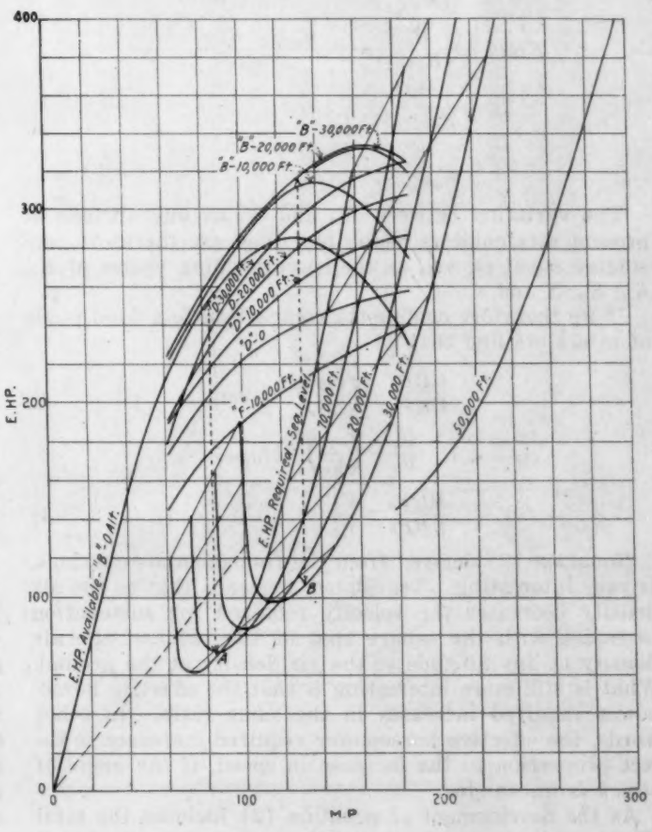

FIG. 2

analysis of the fundamental equations of flight. In this analysis the following notation is employed:

D = the drift
EHP = the effective horsepower required
H = the head resistance
$K_h = 0.003$
K_x = the drift factor of the wing
K_y = the lift factor of the wing
L = the lift
S = the area of lifting surfaces
s = the parasite resistance area
T = the thrust in pounds
V = the velocity of flight in miles per hour
W = the weight of the airplane in pounds
Δ = the air-density factor

$$D = K_x \Delta S V^2$$

$$EHP = \frac{TV}{375} \qquad (1)$$

$$H = K_h \Delta s V^2$$
$$L = K_y \Delta S V^2$$
$$T = D + H$$

$$V^2 = \frac{W}{K_y \Delta S}$$

By substitution equation (1) becomes

$$EHP = \frac{\Delta W^{3/2}}{375 (K_y \Delta S)^{3/2}} \times K_x S \cdot K_h s$$

$$= \frac{W^{3/2}}{(K_y S)^{3/2}} \times \frac{K_x S \cdot K_h s}{375 \Delta^{1/2}}$$

Introducing the subscript o for standard conditions at sea level, and the subscript a for standard conditions at the altitude A, we obtain

$$EHP_o = \frac{W_o^{3/2}}{(K_{yo} S_o)^{3/2}} \times \frac{K_{xo} S_o \cdot K_{ho} s_o}{375 \Delta_o^{1/2}}, \text{ and}$$

$$EHP_a = \frac{W_a^{3/2}}{(K_{ya} S_a)^{3/2}} \times \frac{K_{xa} S_a \cdot K_{ha} s_a}{375 \Delta_a^{1/2}}$$

$$V_o^2 = \frac{W_o}{K_{yo} \Delta_o S_o}, \text{ and}$$

$$V_a^2 = \frac{W_a}{K_{ya} \Delta_a S_a}$$

The variation between W_o and W_a at any altitude at present attainable is negligible; they are therefore considered equal as well as the corresponding values of K_h, K_x, K_y, S and s.

If we therefore confine the comparison to a fixed angle of attack we find that

$$\frac{EHP_a}{EHP_o} = \left(\frac{\Delta_o}{\Delta_a}\right)^{1/2}, \text{ but}$$

$$\frac{V_a}{V_o} = \left(\frac{\Delta_o}{V_a}\right)^{1/2}, \text{ hence}$$

$$\frac{EHP_a}{EHP_o} = \frac{V_a}{V_o} \qquad (2)$$

Equation (2) derived from the fundamental equations, is very interesting. Translated, it means that as the air density decreases the velocity required for sustenation increases with the square root of the ratio of the air density at any altitude to the air density at the ground. What is still more interesting is that the effective horsepower required increases in the same ratio. In other words, the effective horsepower required increases in direct proportion to the increase in speed, *if the angle of attack is unchanged.*

As the development of equation (2) includes the total effective horsepower required to overcome the combined wing and parasite resistances, it permits the determination of the effective horsepower required at any altitude in a direct and simple manner, either graphically or by computation. The only data required are the effective-horsepower-required curve for the airplane at sea level, and the ratio of the air density at the required altitude to the air density at the ground. For example, suppose that at sea level, at a 4-deg. angle of attack, 150 e.hp. is required at 90 m.p.h. It is required to determine the effective horsepower and V at an altitude where the air density is 0.5 that at sea level.

By computation,

$$\frac{\Delta_o}{\Delta_a} = 2, \text{ hence}$$

$$EHP_a = 150 \times \sqrt{2}$$
$$= 150 \times 1.414$$
$$= 212, \text{ and}$$

$$V_a = 90 \times \sqrt{2}$$
$$= 90 \times 1.414$$
$$= 127$$

Graphically, the new spot on the effective-horsepower curve for a 4-deg. angle of attack will be found on a vector from the origin through the original 4-deg. spot at a point distant from the origin 1.414 times the distance of the original spot, as in Fig. 1.

The diagonals or vectors may be measured on any convenient scale of length. Fig. 2 illustrates the effective-horsepower curve of an actual airplane of clean design equipped with a 400-b.hp. engine. At the surface, with a propeller of 75 per cent efficiency, this plane indicates 154 m.p.h. By the use of the supercharger, if the propeller efficiency remains constant at 75 per cent and the propeller permitted the engine to develop its full number of revolutions per minute, this plane should be capable of making 171 m.p.h. at 10,000 ft., 190 m.p.h. at 20,000 ft., 208 m.p.h. at 30,000 ft. and 233 m.p.h. at 40,000-ft. altitude.

No simple propeller is capable of such performance. If the engine develops its full power at the different altitudes, the propeller working in the rarer atmosphere is unable to absorb the horsepower output at the same number of revolutions per minute and further, the thrust and the propeller efficiency are both affected by the changes in the air density and the speed of advance necessary to sustenation. It therefore becomes necessary to adopt some device which will permit the power to be absorbed at not more than a certain maximum number of revolutions per minute of the engine. Two methods are available; one, already in use, is the variable-pitch propeller; the other requires the introduction of a variable-speed device or shift gears. Another device which is purely a subterfuge is to over-propeller the airplane at the ground surface, but this seriously handicaps surface performance and climbing power.

Airplane Propellers

To illustrate the importance of the propeller side of the problem I have chosen a definite propeller of the variable-pitch type for which data are available. This is the one for which data are given in report No. 30 on Experimental Research on Air Propellers, Part II of the Fourth Annual Report of the National Advisory Committee for Aeronautics, 1919. These data are based upon investigations laid out by Dr. W. F. Durand at the wind tunnel at the Leland Stanford University, and executed under the direct charge of Prof. E. P. Lesley. The characteristics of this propeller are given in Figs.

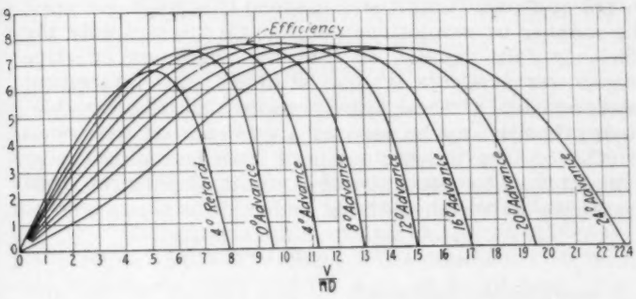

FIG. 3

3 and 4. These figures are based upon the metric system, the French unit of power being about 0.986 of our standard.

taken and shown on Fig. 2. From an inspection of the curves of Figs. 2 and 6 it appears, as was to be expected, that the propeller can only absorb the horsepower developed by speeding up in the thinner atmosphere, or by being twisted so that its pitch is increased.

It is regretted that the Durand data do not permit the graphical application beyond a speed of 300 km. per hour, although even in this range it appears that the normal form of the propeller develops increased power up to about 170 m.p.h., but it does so by permitting the engine, whose normal speed is 1800 r.p.m., to run up to 2100 r.p.m. Even the *C* setting runs it up to 2000 r.p.m. at this speed of advance. The higher pitches help to hold down the number of revolutions per minute as the speed of advance and the altitude increase. The *F* setting permits 191 m.p.h. to be obtained at 1540 r.p.m., but the

TABLE I.—PROPELLER DATA

Altitude		Velocity		B					C					D					F					H				
m.	ft.	km. per hr.	m.p.h.	Speed, r.p.m.	Propeller Efficiency, per cent	B.hpt.	E.hpt.	E.hps.	Speed, r.p.m.	Propeller Efficiency, per cent	B.hpt.	E.hpt.	E.hps.	Speed, r.p.m.	Propeller Efficiency, per cent	B.hpt.	E.hpt.	E.hps.	Speed, r.p.m.	Propeller Efficiency, per cent	B.hpt.	E.hpt.	E.hps.	Speed, r.p.m.	Propeller Efficiency, per cent	B.hpt.	E.hpt.	E.hps.
0	0	100	62	1330	63	335	211	214	1150	65	293	191	194	1040	65	265	172	174	870	62	222	138	140	730	55	186	102	103
		150	93	1430	72	362	261	264	1240	75	313	235	238	1090	75	287	215	218	870	74	222	164	167	720	71	182	129	131
		200	124	1570	73	385	281	285	1370	77	342	263	267	1190	78	302	235	238	960	76	243	185	188	730	75	186	140	142
		300	186	1910	53	432	228	231	1660	56	382	214	217	1430	56	362	203	206	1150	64	293	188	..	850	46	217	100	101
2,000	6,560	100	62	1460	60	362	217	220	1270	61	337	206	209	1150	60	293	176	178	990	57	250	143	146	812	49	206	101	102
		150	93	1560	70	382	267	270	1350	72	339	244	247	1190	63	302	220	223	965	71	245	174	177	815	66	208	137	139
		200	124	1680	75	403	302	306	1475	78	363	283	287	1290	77	323	248	251	1030	75	262	196	199	815	74	208	154	156
		300	186	1975	57	440	251	249	1700	62	370	230	233	1510	67	372	249	252	1205	69	305	210	213	910	72	231	166	168
4,300	14,100	100	62	1605	56	391	219	222	1410	57	330	188	191	1290	58	323	193	196	1115	51	283	144	146	900	42	228	96	97
		150	93	1690	67	404	271	275	1465	70	363	254	258	1310	70	330	231	234	1085	68	275	187	190	912	63	232	146	148
		200	124	1800	73	417	305	309	1570	75	382	286	289	1390	76	347	264	268	1110	75	282	212	215	912	72	232	160	163
		300	186	2100	72	450	324	320	1805	71	419	297	304	1600	71	390	273	277	1290	75	323	242	245	990	70	250	175	178
7,150	23,450	100	62	1800	51	417	213	216	1600	52	390	203	206	1470	50	365	183	186	1275	43	321	138	140	1005	35	255	90	91
		150	93	1870	64	427	274	271	1630	66	395	261	265	1485	66	367	242	245	1250	63	315	198	201	1060	56	269	151	153
		200	124	1970	72	440	316	312	1715	74	407	301	305	1530	73	376	275	279	1240	72	313	225	228	1050	68	267	181	184
		300	186	2300	71	460	326	322	1960	73	..	..	..	1710	76	406	308	312	1400	77	349	269	272	1080	75	275	206	209
9,000	29,500	100	63	1930	50	435	217	215	1712	50	409	204	207	1600	47	390	183	186	1370	39	343	134	136	1010	30	212	82	83
		150	93	1990	63	442	278	271	1750	65	412	268	272	1600	63	390	246	249	1370	59	343	202	205	1150	51	293	150	152
		200	124	2080	60	449	270	268	1810	70	419	293	297	1650	72	398	287	291	1350	70	339	237	240	1150	65	293	190	193
		300	186	2200	71	456	324	320	2140	73	..	..	..	1800	77	417	322	326	1460	76	362	275	279	1160	71	292	207	210
11,250	36,900	100	62	2075	47	448	211	209	1950	44	..	..	..	1780	32	415	150	152	1500	34	370	126	128	1150	26	293	76	77
		150	93	2150	60	454	272	276	..	....	..	..	..	1760	59	412	243	246	1550	55	380	204	212	1280	46	322	148	150
		200	124	2240	68	457	311	307	..	....	..	..	..	1800	69	417	288	292	1510	66	372	245	248	1300	60	326	196	199
		300	186	2470	75	460	345	341	..	....	..	..	..	1950	76	..	..	..	1580	75	387	290	294	1300	73	326	238	241

The brake-horsepower characteristic for the engine used in the computation is plotted in Fig. 5, in which is shown the revolutions per minute and brake-horsepower for both the French and United States units. Applying the characteristic to the logarithmic diagrams of Fig. 4, the performance for each setting *B*, *C*, *D*, *F* and *H*, of a 10-ft. variable-pitch propeller has been determined for different altitudes and velocities of advance. The results are tabulated in Table I. All the data given in the Table I have been graphically determined and are subject to the errors of such a method. The resultant data are reasonably accurate and consistent. Their analyses show the results to be expected from the use of this type of propeller in conjunction with an engine equipped with a supercharger. So many variables are involved that it is difficult to arrive at a comprehensive plot.

Fig. 6 is based upon the altitude in meters, showing the effective horsepower available for each setting, with a variation in the speed of advance of 100, 150, 200 and 300 km. per hour. It gives a direct insight to the influence of altitude and speed of advance upon the performance of the engine as restricted by the propeller action. The revolutions per minute and efficiency are indicated for each spot. It is interesting to trace their variations. From the plots of Fig. 6 cross curves are reduced number of revolutions per minute, together with the decreased efficiency, reduce the effective horsepower

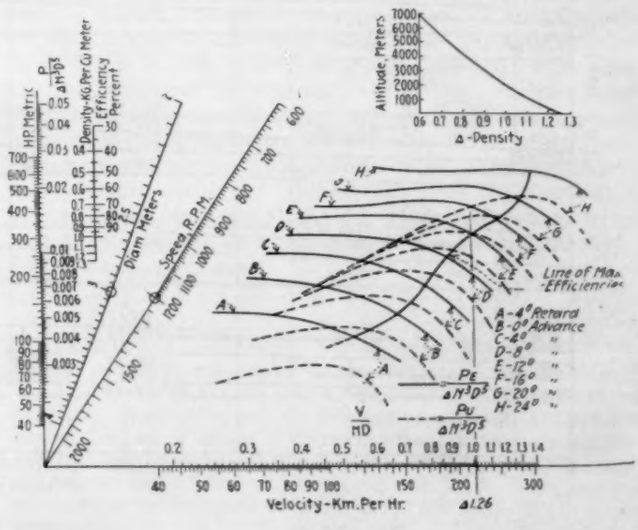

FIG. 4

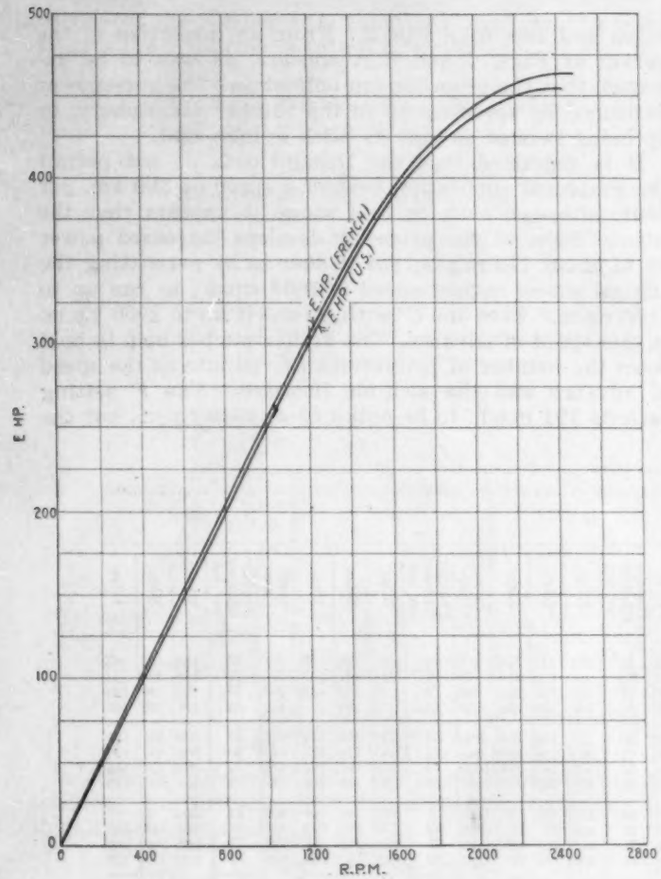

FIG. 5

to 285 at 30,000-ft. altitude. Beyond this point, although the number of revolutions per minute rises rapidly the efficiency falls rapidly, so that the maximum effective horsepower available is soon attained. An interesting interpretation of these conditions is that the variable-pitch propeller can be used as a governor on wide-open throttle to keep the engine speed from becoming excessive and that, to obtain the best results, departures from the normal forms should only be made for this purpose.

CLIMBING AND FLYING SPEEDS

A remarkable indication in this respect is that the climbing rate with a supercharged engine, on an airplane of the type chosen for illustration, should improve with altitude. This is indicated by the reserve horsepower shown at the points *A* and *B*. Thus, at *A* the reserve power is about 182 hp., and at *B* it is 218 hp., or a 20 per cent gain in the rate of elevation, while the best speed for climbing increases from 84 to 130 m.p.h. Another interesting indication is that, with the propeller selected, the maximum speed at the ground surface should be about 150 m.p.h., while at 30,000-ft. altitude this speed should increase to more than 200 m.p.h.

The suggestion of variable-speed gearing, or shift gearing to hold the normal form of blade to a proper *V/ND* ratio while still absorbing full engine power, naturally develops. Particularly when we note that even at 186 m.p.h. all settings of the variable-pitch propeller have passed their peaks of efficiency. By the adoption of these means, such an airplane as was assumed in the example might make 260 m.p.h. at about 50,000-ft. altitude. Travelling east at 30,000-ft. altitude, there is stated to be an average wind of over 100 m.p.h. We may thus reasonably predict 350 m.p.h. at an altitude of

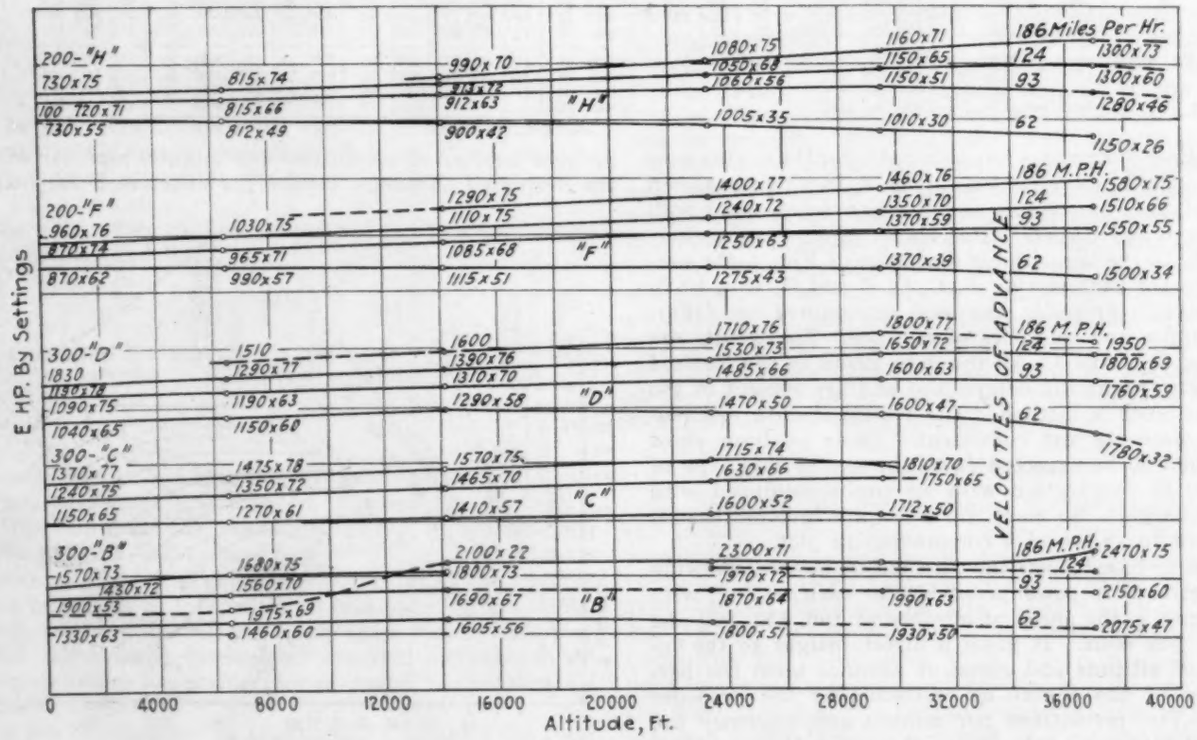

FIG. 6

50,000 ft., which would make the distance from New York to London or Paris a 10-hr. trip.

Miscellaneous Factors

Let us now consider a few other factors. In such thin atmosphere the effects of disturbance upon the airplane are greatly augmented and the finest type of instruments adjusted to work at low temperatures and pressures must be used. The ordinary magnetic compass goes wild if turning is present and loses accuracy if the plane is inclined. The inclinometer also fails to indicate true levels when turning and, as at such altitudes the surface is indistinct or often obscured by clouds, surface indications can no longer be depended upon to determine the true altitude of the plane and drift observation of the surface, to determine whether or not the true course is being followed, becomes almost impracticable.

The following instrument equipment is indicated as being necessary:

A turning indicator with positive action
A highly sensitive compass
A sensitive inclinometer
A drift meter
A radio compass
The usual instruments showing performance of the power plant
Special oxygen equipment and clothing for the pilot and passengers
Increased cooling capacity for the radiating system

The useful load will then be reduced by the extra equipment, additional radiating capacity, supercharger gear and the increased weight of a variable-pitch propeller, or of change gears, if used. Further, not everyone is fitted to exist and act normally under the conditions that will be encountered.

Aside from the advantages to be gained from the use of the supercharger and the variable-pitch propeller, as outlined, all the advantages of a reduction in horsepower at the surface by the elimination of resistance become augmented at great altitudes, as indicated by the law of increased power required. An interesting point, almost forgotten in the desire to demonstrate possibilities at high speed, is the modification of the cruising speed. Thus, at sea level, the best cruising speed would be about 75 m.p.h.; at 30,000-ft. altitude it would increase to 130 m.p.h. The effective horsepower required would, however, increase from 62 to 106, the net effect being that the cruising radius is substantially unchanged.

We thus arrive at the conclusions that by increased altitude we may expect a greatly increased speed, but can hardly hope to increase the radius of action. In fact, unless the wind at great altitudes favors the direction we desire to take, we shall probably lose because, while climbing, we must lift a load of gas and oil, thus expending energy to lift a weight that will be consumed in flight, and which will not be available to return the equivalent energy in descent. It is not so remarkable that this

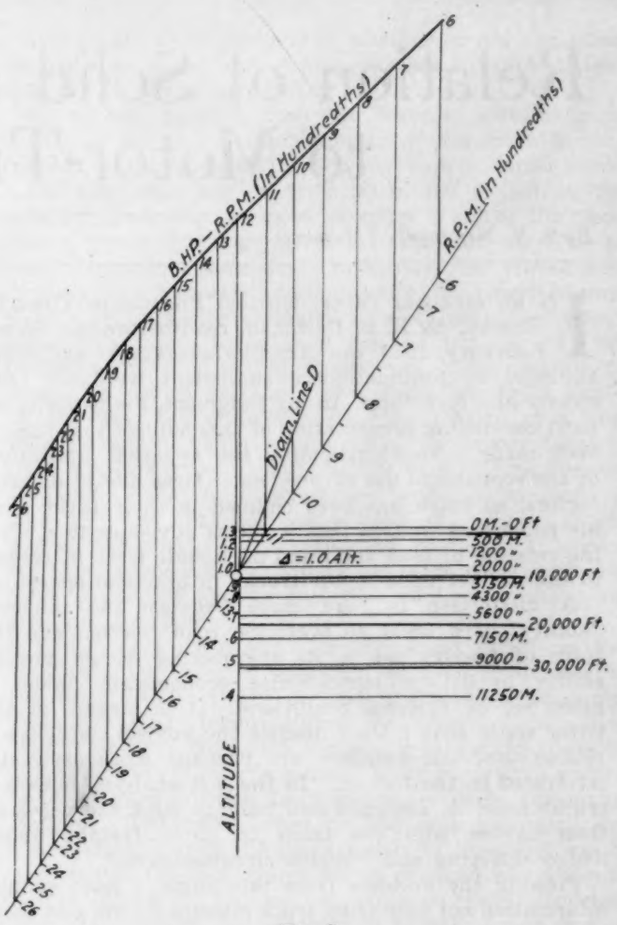

Fig. 7

is true, for it has already been proved for the ordinary type of engine. The reason is obvious. It is that the effective horsepower required for flight depends upon the airplane, and the brake horsepower required depends on the airplane's effective horsepower and the propeller efficiency. Under these conditions the supercharger has practically no influence.

It appears that the variable-pitch propeller is principally useful as a governor at high speed. If it were not for limits to the number of revolutions per minute, the basic form of propeller carefully selected will give greater effective horsepower than the modifications available in the variable-pitch propeller. It also appears more than probable that shift gears would permit a most efficient combination for a specific case. Whether or not they should be adopted will depend upon the possibility of developing and applying such gears without such an increase of weight as would make the net result a handicap instead of an asset.

FOREIGN AUTOMOBILE SALES

According to the National Automobile Chamber of Commerce, this country exported 67,106 passenger cars, valued at $73,642,035 in 1919 as against 36,936 cars, valued at $36,278,292 in 1918. The heaviest increases were shown in South American takings. Canada, the largest buyer of American cars, took 8222 passenger cars and 1596 trucks. Truck exports numbered 15,467, valued at $35,099,079, as against 10,308, valued at $26,814,952 in 1918.

OIL EXPORTS TO GREAT BRITAIN

The principal exports of oil products to Great Britain in 1919 were 71,474,064 gal. of gasoline, 166,630,047 gal. of kerosene, 69,889,334 gal. of lubricating oil and 197,278,894 gal. of fuel oil. This is a decrease of approximately 50,000,000 gal. of gasoline, 45,000,000 gal. of lubricating oil and 516,000,000 gal. of fuel oil, compared with 1918. Kerosene exports show an increase of about 3,100,000 gal.—*Wall Street Journal.*

Relation of Solid and Pneumatic Tires to Motor-Truck Efficiency

By S. V. Norton[1] (*Member*)

Chicago Truck and Tractor Meeting Paper

In an excellent paper, entitled Pneumatic Tires for Trucks,[2] by B. B. Bachman, read before the Society February, 1919, the principal advantages and disadvantages of pneumatic-tire equipment were set forth clearly and forcefully. In my judgment, his paper is the most convincing presentation of this subject that has yet been made. Notwithstanding the apparent limitations of the economical use of pneumatic tires due to external factors, so much has been claimed in their favor since his paper was written that it seems advisable to analyze the relation of both solid and pneumatic tires in respect to their effect upon motor trucks in practical operation.

A distinction is here made between the inherent "ability" of a truck to overcome road friction and the force of gravity due to its engineering design and its ability to deliver merchandise economically under a given set of external conditions. It is largely in the latter sense that I shall discuss the subject, although I realize that the members are perhaps more especially interested in the former. In the last analysis, however, trucks must be designed and built to meet the needs of their buyers, who use them to move freight under widely differing and complex circumstances.

Viewing the problem from this angle, I have sought information not only from truck manufacturers and their engineers, but from truck salesmen and operators in all parts of the country, as well as from tire dealers and those upon whose local service in the field the continued and successful operation of the truck depends. The information presented is not theoretical, nor based upon the experiences of selected operators whose delivery problems would invariably point to the same conclusion, but is rather a composite of the opinions of hundreds of truck operators engaged in handling all kinds of merchandise, and of hundreds of men whose business it is to help keep those trucks running economically. Because of the concentrated study that is being given to all phases of motor transportation, some factors in the problem are almost as variable as a kaleidoscope. Hence, conclusions which may appear sound today may have to be modified by changes that are gradually but constantly taking place. For instance, truck design is being altered and improved. Tires are being built better and stronger. Roads are being improved, while experience is pointing the way to the more intelligent use of motor trucks through systems and devices heretofore unknown. It therefore seems worth while to view the question of truck tire equipment in the light of recent experiences of many operators and service men, to get a clear idea of the advantages and limitations of each type.

General Functions of Tires

The functions of tire equipment are: To secure traction, cushion the mechanism and the load and protect the road. From the truck operator's viewpoint the first two are of more importance than the third, although it is becoming increasingly necessary to safeguard the taxpayers' investment of millions of dollars in improved highways through proper restrictions upon the vehicles that use them. To perform these functions, solid, cushion and pneumatic types of tire are available. The general knowledge of the construction and peculiarities of each type makes it unnecessary to describe them, except to say that the cushion tire is in reality a solid tire, usually made from a specially resilient rubber compound, so designed in contour or internal construction as to be soft and yielding under pressure. Its construction generally renders it less rugged and hence more susceptible to early failure under severe service conditions. Since there are relatively few cushion tires in service at present, we may profitably confine our discussion to the solid and pneumatic types.

At present, the accepted field for pneumatic tires is on trucks up to 1½ tons capacity, and for solid tires it is on trucks of 3½ tons or over. Between these two capacities the field is debatable, and the choice cannot be made intelligently without a careful analysis of the important factors involved in each individual case. If the operators of trucks in this debatable field could surely avail themselves of all the advantages claimed for pneumatic-tire equipment, no trucks would be found on solid tires, since the claims embrace nearly everything the truck owner desires. Let us review the claims made on behalf of the tires themselves and then study them in relation to various external factors which should have an equal if not greater bearing upon the choice of equipment.

From several hundred truck-tire salesmen, as well as truck operators throughout the United States, whose opinions were asked as to the principal advantage to be gained from the use of pneumatic tires in the debatable field above described, the following table shows the reasons given with the percentage of replies for each:

	Per cent
Greater traction	40
More cushioning	28
Higher speed	21
Lower repair bills	5
Saving in gasoline	4
More work possible	2
	100

Other reasons were given for the use of pneumatic tires, but they were thought to be of secondary importance. They were

(1) Less breakage of loads
(2) Reduced fatigue of drivers
(3) Less depreciation of trucks
(4) Reduced depreciation of roads
(5) Adaptability of trucks to farm use
(6) Lighter weight trucks possible
(7) Increased earning power

[1] B. F. Goodrich Rubber Co., Akron, Ohio.
[2] Printed in The Journal, April, 1919.

Deciding Factors in Tire Choice

It is apparent that a careful study should be made of all the factors involved before deciding which type of tire to use. For the purposes of this discussion the factors may be divided into three groups; engineering features, practical operating features and features of tire service in the field. In taking up the engineering aspects I speak briefly and frankly as a layman and not as a truck engineer. Before changing tire equipment from solid to pneumatic it should be realized that to gain certain possible advantages other definite disadvantages must be faced. First, the wheels of the vehicle must be cut down to receive pneumatic tires. The cost of this will vary according to local conditions, but it is a large item of expense. As the pneumatic tire has a larger actual than nominal diameter, and since in many cases a pneumatic of larger nominal diameter must be used than is required for a solid tire, to secure the necessary carrying capacity, proper allowance should be provided for both body and fender clearance. It should also be remembered that the larger sectional diameter of the pneumatic tires will affect the steering clearance and that the truck will be unable to turn in so short a radius as it did on solid tires. This is especially important in negotiating turns in narrow streets and alleys, as well as in garages with limited floor space. As the larger diameter of the pneumatic tires will affect the gear reduction, the change will have a corresponding effect on the mechanical ability of the truck. If the change is made, will the truck be able to "make the grade" so far as particular problems are concerned? Will it materially affect the pay-load capacity of the truck? Will it reduce ability to carry trailers? What will be the effect upon the engine?

The increased maximum speed due to the larger diameter of the pneumatic tire will be relatively slight, provided the engine is governed to run at the same speed as formerly. If the change is made to get more speed, either the gear ratio must be reduced and the ability of the truck thus still further reduced, or the governor must be opened and the engine speed increased. There is danger here, however, as speed induces extra vibration, joints begin to loosen and before long the engine may be literally racked to pieces.

As the engines in some trucks now have pressure-feed oiling systems, they can more safely withstand the extra speed, so far as lubrication is concerned, although this feature should be carefully investigated, as there is danger of damage from this cause with resultant expense. Still another factor which should be considered is the tax upon the cooling system if the engine is speeded up. Again, additional speed calls for greater braking ability. Before changing tire equipment assurance is necessary that with increased truck speed and the limitations imposed on the diameter of the brake drums by the reduced diameter of the wheels themselves, the machine will still have sufficient braking ability. Brakes designed for slower speeds but used under more severe conditions, will inevitably require more frequent renewal and may not even safely perform their required function. In fact, an engineer of one of the larger tire companies, advocating the use of pneumatic tires on trucks, says

> On account of the comparatively high speed of the pneumatic-equipped trucks, it is necessary to equip them with brakes having 100 per cent more capacity than is the case with solid-tired trucks.

The question for decision is whether or not the truck can be so equipped and, if not, whether it can be safely operated on pneumatic tires.

Of no less moment than the features already mentioned, so far as the dependability of the truck is concerned, is the question of the air supply, since pneumatic tires may require from 90 to 160 lb. per. sq. in. inflation pressure. As hand pumping is out of the question, a power-driven pump on the truck, or one close at hand, becomes a necessity. Relatively few trucks now running can properly accommodate a power pump. With a transmission arranged so as to permit of power take-off, a pump attachment can be put on. If the transmission is mounted amidships, it is possible to provide a device to take power from the drive shaft. If, however, the truck has its transmission in a unit with its engine, with no provision for power take-off, there appears to be no satisfactory way of attaching an air-pump, since the magneto and water-pump shaft is generally too light for power take-off. There is, of course, the possibility of adapting an electrical system for this purpose, but this does not seem practicable, because of its cost and the fact that such apparatus is not standard practice.

While these mechanical considerations apply particularly to trucks now in operation on solid tires, most of the same problems are involved in changing the equipment on trucks manufactured but unsold. The buyer usually looks to the agent for advice regarding tires; he should therefore satisfy himself that the agent's counsel is based upon positive facts and endorsed by the manufacturer. Otherwise, more or less disappointment and dissatisfaction over the performance of the truck can be expected if the tire equipment is changed to pneumatic before delivery. To sum up, since so many important technical features are involved, it is well to seek the advice of the truck builder before changing equipment from solid to pneumatic tires. No one else knows so well the probable effects on various parts, nor can anyone advise more intelligently as to the probable loss or saving that such a move would entail upon the mechanism of the truck.

Let us next consider the practical operating features that must be taken into account in determining which type of tire equipment will make the truck most efficient in service. Broadly speaking, the efficiency of a truck in performing its function depends upon the amount of time or money, or both, that it saves for the shipper, as compared with any other means of haulage. While it is difficult to separate all the factors bearing upon these two items, they may be roughly classified as follows:

Factors Affecting Time	Factors Affecting Cost
(1) Distance of hauls	(1) Amount of pay-load and overload
(2) Traffic congestion	(2) Condition of roads; effect on tires and truck
(3) Speed of delivery	(3) Number of trips per day
(4) Regularity of delivery	(4) Cost of operation
(5) Condition of roads; effect on speed of truck	(5) Cost of upkeep
(6) Number of trips per day	(6) Cost of substitute equipment
(7) Time out for repairs, etc.	

The question of how tire equipment bears upon these factors can only be answered after careful analysis of each particular case. However, certain principles can be applied to all cases. To begin with, from 75 to 225 per cent more must be paid for pneumatic than for solid tires.

The latter figure includes the cost of spare tires, which are indispensable at the present stage of development. So far as is known, there are no dependable figures indicating the relative cost per mile of the two types, because pneumatic truck tires have not been used long enough to make reliable comparisons. From such information as is obtainable, however, it is my belief that it will cost from two to three times more per mile to run on pneumatic than on solid tires. To offset this increased cost there should be a corresponding or greater saving in one or more of the factors already enumerated, as affecting the operating efficiency of the truck.

How Tires Affect Time Factors

Let us now inquire how pneumatic tires may affect the time factors, assuming that the mechanical features of the truck are such as to permit of their use. If the truck is engaged in long-distance hauling with relatively few stops, pneumatic tires will almost invariably save running time, due to the fact that they absorb the road shocks so much more easily than do solid tires. By theoretical tests in our laboratory we have found that, for a given load, pneumatic yield over four times more than solid tires. Hence a truck can be driven over long distances at much higher speeds on pneumatic than on solid tires without fear that it will be racked to pieces. It should also be noted that the drivers' fatigue in such cases is far less on pneumatic than on solid tires. In fact, some operators have considered this so important that they have placed cushions with special springs in their drivers' seats.

Up to the present, however, very few trucks as compared with the total number in operation, certainly less than 5 per cent, are engaged in long-distance hauling. The great majority of trucks operate in cities where traffic congestion is such that they cannot possibly attain a speed of over 10 m. p. h., while their average speed is from 5 to 8 m. p. h. For such speeds there is no possible saving in the list of time factors to offset the extra cost of running on pneumatic tires. Moreover, the gain will be still further reduced by idle time at loading and unloading points. In many cities an effort is being made to reduce the maximum legal speed at which trucks may operate because of the many serious accidents attributed to them. Hence, increase of driving speed within city limits may be prevented by ordinances limiting the speed of trucks. Light delivery vehicles, running on pneumatic tires, are sometimes operated at higher speeds than are legal, but these do not properly come within the "debatable field" and are not considered as dangerous as the heavier vehicles.

In certain kinds of business such as the wholesale delivery of milk, gasoline, ice, etc., the regularity of service is the most important factor. Here the use of heavy-duty pneumatic tires is fraught with danger, due to the possibility of delays caused by punctures and poor tire service. Many operators in these and kindred lines have said that it is more important to deliver goods regularly and on time than to save a few dollars on truck upkeep. Failure in this means loss of the customer. One large truck-fleet operator in this group uses no pneumatic tires of over 6-in. section because solid tires on some good make of cushion wheel have always given him greater satisfaction at less cost than have larger pneumatic tires. Such equipment usually lasts for more than 2 years without trouble.

The condition of the road surface has a very important bearing upon the time element, for it has a direct effect upon the truck speed. In fact, under certain circumstances, the increased traction afforded by the heavy-duty pneumatic tire makes it possible to operate the truck, while if it is equipped with solid tires it cannot be driven at all. This is particularly noticeable in rural districts where there are no hard-surfaced roads.

In the farm lands and citrus groves of the South, where there is so much sandy bottom and so little surfaced roadway, it is practically impossible to operate a truck equipped with solid tires. However, a truck equipped with heavy-duty pneumatic tires can operate practically anywhere and is not dependent upon the highway for traction. Under such circumstances, the ability gained by the use of the pneumatic tire is worth 100 per cent more than that of the solid tire, no matter what its cost, for the latter is well-nigh useless. It must not be supposed, however, that there are no circumstances under which pneumatic tires will fail to perform their function unassisted by anti-skid equipment. The need for proper tire and chain clearance in changing from solid to pneumatic tires is again apparent, for, if due provision is not made, the time factor may occasionally be seriously and adversely affected.

One of the advantages most frequently mentioned is the greater number of trips per day which can be obtained from a truck equipped with pneumatic tires. So far as this factor alone is concerned, there is no doubt that the advantage is in favor of the pneumatic tire.

One more important factor affecting the time element is the number of hours the truck is laid up for repairs. Let us consider separately the time lost on account of tire trouble and that for all other reasons. In comparing the relative amount of time out for tire trouble for solid and pneumatic tires, the advantage lies wholly with the former. Barring occasional lay-ups caused by defective material or workmanship, solid tires can be depended upon to give uninterrupted service from the time they are applied to the time they have worn down to the renewal point. An appointment can then be made in advance with a tire service station without seriously disturbing regular truck service, and the worn tires replaced with new ones. There is hardly a sizeable city in the United States that does not have one or more hydraulic presses for this purpose and well-equipped service stations with ample stocks of solid tires. It is therefore only a question of laying up the truck a few hours at rare intervals, which can be planned so as to interfere very little, if at all, with the regular use of the truck. While the condition of the roads over which the truck operates influences to a certain extent the mileage delivered by solid tires, and hence the frequency of lay-ups for renewals, this factor is far less important for solid than for pneumatic tires.

Owing to the comparative vulnerability of pneumatic tires, they are far more likely to require time out for repairs and replacements. In the first place, they cannot withstand the same amount of overloading as solid tires, and when they are overloaded they are especially apt to give out. Such "failures" usually occur when the truck is in action and away from a service station. If the operator has a spare tire he may make the change on the road, although the evidence seems to indicate that it requires a skilled mechanic to do this and that it cannot be done easily or quickly. Most operators of trucks find it impossible to change a tire in less than 1 hr. under best conditions; under bad conditions it requires 2 or 3 hr. Punctures do not seem to be so frequent or so costly in point of time as blow-outs due to cutting and

chafing of side walls from ruts, as well as to underinflation and overloading. While solid tires are cut and torn by ruts, they are not so dangerously weakened by the process, and they rarely give out unexpectedly. If regularity and dependability of service are sought, these will be far more likely to be secured with solid rather than with pneumatic tires.

In comparing the time out for causes other than tire trouble, we find a variety of conflicting claims, although it seems to me the evidence favors the use of pneumatic tires. On the other hand, some claim that the use of pneumatic tires accelerates the wear of certain parts such as bearings, bushings and steering knuckles and that a correspondingly greater amount of time is required for their adjustment and renewal. Moreover, many owners state that the use of pneumatic tires on trucks causes their drivers to overspeed and to take more dangerous chances that result in accidents and time out for otherwise unnecessary repairs, than is the case with solid tires.

How Tires Affect Cost Factors

In discussing the factors affecting the time element I have purposely avoided reference to the cost of the time, although I realize that these items all have a relative money value. In turning to the factors affecting the saving of money, it will therefore be necessary to refer to that aspect of some of the time features already mentioned. Moreover, although the two are so closely related that it may be difficult to distinguish between them, let us next consider the effect of solid and pneumatic tire equipment on the various money factors involved.

The amount of work a truck can perform, and hence the saving or profit it will show, depends largely upon the amount it can carry, or its pay-load. It is generally held that the more the truck carries, the more it earns or saves. The result of this belief is the well-nigh universal tendency to overload trucks beyond their rated capacity. In fact, many operators maintain that they cannot use trucks profitably unless they overload them. I shall not here attempt to debate the wisdom of this philosophy, but in analyzing the problem the fact must be faced that nearly all operators do overload their trucks and there seems to be no simple or effective way to prevent it. It is not uncommon to find trucks carrying twice their rated capacity.

When it comes to durability under this usage, there seems to be no doubt that solid tires will not only carry heavier overloads but will last longer in such service. All agree that the life of the heavy-duty pneumatic tire is short when overloaded. This seems the most important and least understood factor in the entire list. Apparent savings may be off-set or overbalanced by the additional trips that become necessary when an overload cannot be carried. The use of pneumatic tires automatically places a lower limit upon the pay-load which can safely be hauled under *any* conditions.

Closely allied to the cost of overloading pneumatic tires is that of underinflation. In this case the constant and extreme flexing has a tendency to weaken the side wall, making it much more likely to fail in service. It is held that drivers should give the same attention to tires as they give to water in radiators, oil in engines or gasoline in tanks. This is only another way of saying that the driver must be careful not to abuse his truck. Those who employ drivers realize how difficult it is to get men to watch these details, and the fewer such points requiring the driver's care and attention the more likely it is that the truck will run continuously and economically. While solid tires are not invulnerable, they are more nearly fool-proof and less expensive to maintain in working condition.

In addition to the likelihood of incurring expense from overloading and underinflation, there is the danger of ruining pneumatic tires from running them when loaded or overloaded after they have been punctured or blown out. It is not uncommon for drivers to ruin practically new tires by not stopping trucks as soon as tire trouble is suspected. A single blowout or puncture under such circumstances may cost from $25 to $100.

The condition of the roads over which the truck travels not only affects the speed or time factor, but has an important bearing upon the life of the tires and hence upon their cost. Pneumatic are subject to more damage than solid tires when run over roads with deep ruts because of chafing and cutting of the sidewalls.

In attempting to collect data as to mileage on pneumatic tires, many varying claims and little information based on records of a dependable nature were found. Operators are apt to exaggerate both high and low mileages, due to personal satisfaction or disgust, as the case may be. Most operators when questioned closely regarding averages will admit that they have not used pneumatic long enough to obtain reliable figures for comparison with solid truck tires. Hence, none but general conclusions are possible at this time. The mileages reported, from Maine to California, varied from 200 under adverse conditions such as bad roads, overloads, careless drivers, etc., to 25,000 miles on lighter trucks, over good roads and with proper care. Tires in city service usually give better mileage than those in use in the country. With rare exceptions the mileage delivered by solid is considerably greater than that from pneumatic tires in the same class of service.

Where the earning capacity of the truck is concerned, as judged by the number of trips per day, the advantage seems to lie with pneumatic-tire equipment, provided the runs are long enough and not restricted by such factors as traffic congestion and delays at terminals. In most cases the increased speed made possible by pneumatic tires can be converted into greater earning capacity, with little or no increase in overhead expenses.

As before suggested, there are certain conditions under which trucks on pneumatic can make trips when those on solid tires cannot be operated. Hence their earning capacity is just so much greater. But a new and interesting argument has recently been advanced on behalf of pneumatic tires, due to certain changes in the conduct of the business of farming. The ever-increasing use of gasoline engines for tractors, threshing machines, etc., requires the delivery of gasoline and oils direct to the farmers' door or barn. Oil men who own their own trucks and work on a purely commission basis frequently find it necessary to drive through the farmers' barnyard. It has been noted that trucks having pneumatic not only negotiate the unpaved roadways more easily, but do less damage than those having solid tires, and hence are looked upon with more favor by the farmers they serve.

When considering the relative effects of solid and pneumatic tires on the cost of operation and upkeep, a wide variety of opinions are expressed but very few conclusions based upon accurate cost records. In every other kind of business an intelligent analysis based on cost figures is considered necessary in arriving at conclusions. But few truck operators have yet realized the value of such records as applied to the cost of operation

and maintenance of trucks. Hence the reliable data available are meagre.

Let us briefly examine the items which should be included in such costs, and consider how they are affected by solid and by pneumatic tires. The following items are usually not affected by tire equipment:

(1) Interest on investment
(2) Insurance
(3) Taxes and license
(4) Garage
(5) Supervision
(6) Wages of driver
(7) Wages of helper

Those shown below may vary according to the type of tires used.

(8) Depreciation
(9) Gasoline
(10) Oil
(11) Tires
(12) Repairs due to (*a*) wear and (*b*) accident

Considering these in the order given, there are, so far as known, no dependable figures covering depreciation upon which to make comparisons as no trucks have been run long enough on pneumatic tires to determine their effect on the ultimate life of the truck. While there is a difference of opinion among engineers, most maintain that the increased engine speeds of trucks designed for use on solid but changed to pneumatic tires will tend to wear out all moving parts more quickly than if the tires had not been changed. As to the relative consumption of gasoline and oil, very few reliable figures are available, but the best informed operators are inclined to feel that there is little if any saving in these items, particularly on short hauls. On long hauls, however, the advantage seems to lie in favor of pneumatic tires.

When it comes to cost of tires there is no question. The cost of pneumatic averages from two to three times that of solid tires. This is due to the higher initial cost of the equipment and the spare tires, their greater susceptibility to abuse and accident and their lower average mileage. It is, of course, possible to have pneumatic tires repaired and re-treaded, but this process has not yet been satisfactorily worked out for solid tires, at least to the point that is considered dependable or economical. The question of tire service, however, including all these features, will shortly be discussed.

Truck Repairs

So far as the cost of truck repairs is concerned, comparative data of a reliable nature cannot be obtained, for in most cases trucks equipped with pneumatic tires have not been used long enough to make satisfactory comparisons. The evidence indicates, however, that, excepting the engine, repairs will cost much less for trucks using pneumatic than for those using solid tires, due to reduced vibration. If the engine is not run at excessively high speeds or continually overworked, it will prove less subject to damage if pneumatic tires are used.

Dependable figures cannot yet be obtained on the relative cost of renting substitute vehicles to replace trucks using pneumatic and solid tires which have been laid up for repairs. A superintendent of a large truck fleet using both types states that he lays up solid-tired trucks four times a year for overhaul, while pneumatic-tired trucks are laid up only three times. In any event the variation in this item of expense will not be large, provided the trucks are carefully inspected and maintained.

Summing up the factors affecting the saving of time and money, the conclusion is reacned that no general claims in favor of pneumatic-tire equipment on trucks coming generally within the debatable field can be substantiated, and that the work to be done by each specific installation must be analyzed carefully before either type of tire can be safely considered the more economical.

Having reviewed the engineering and practical operating features, let us now enumerate the operator's difficulties concerning tire service. As the nature and extent of service for the maintenance and renewal of solid tires are well known, it seems unnecessary to comment upon them except to say that years of study and competition have developed this end of the business to a high degree of perfection, so that many well-equipped service stations can be depended upon for instant attention, in many cases by day or at night, whenever it is needed.

The manufacture of heavy-duty pneumatic tires of 6-in. section and larger is, however, a relatively new development. Less than a third of the manufacturers of passenger-car tires have actively started to make heavy-duty pneumatic truck tires, for they realize that the job of building a tire which will stand up under present-day use and abuse is not easy. Moreover, the task is not finished when the tire is removed from the heater. It must be sold to the dealer who, in turn, must not only guarantee the tire, but must place himself in a position to give the truck operator service. This means that he must install a high-pressure air-pump, repair material, molds for vulcanizing and in most cases a service car for emergency calls, for it must be remembered that the pneumatic tire is apt to fail when distant from its base and it cannot be driven home flat. Broadly speaking, to give service means doing whatever is necessary to keep tires in fit running condition. Specifically, it may be divided into three divisions: (*a*) inflation; (*b*) changes and renewals, including adjustments, and (*c*) repairs.

It can be said without fear of contradiction that the tire companies themselves are not as yet prepared to give really efficient service in all parts of the country. In fact, even in the principal cities this phase of the business has not been fully developed. In the smaller towns there are almost no air-tanks or pumps to keep tires properly inflated. Pumps on trucks themselves are reported as not always dependable, sometimes requiring from 15 to 30 min. to secure the desired tire-inflation pressure. Some truck operators have ventured to use pneumatic tires even though they have no pump equipment. One such operator uses a hand pump to put in 60 to 70 lb. per sq. in. air pressure. This allows the truck to be driven slowly to the nearest power pump with sufficient capacity to get the necessary pressure. A second, who has no air-pump on his truck, says he cannot afford to carry spare tires because they use too much space. If caught on a long country trip, he waits until a service car arrives and provides proper tire inflation. Another operator who has a large truck fleet equipped with pneumatic tires keeps a light service car continuously busy carrying tires or compressed air to trucks experiencing tire trouble. A fourth encountered trouble with his demountable tire equipment which he had for a long time carried under heavy inflation. It had then become smaller in inside diameter and could not be put upon the rim. The need for rust-proofing rim parts to facilitate changing has been pointed out to the tire manufacturers. It has also been suggested that if

possible the tires should be made lighter in weight as the larger sizes are very difficult and awkward to handle.

Tire Repairs

By far the most serious and difficult phase of giving service with heavy-duty pneumatic tires, and that which causes the most concern to truck operators, is connected with their repair. In fact, the chief complaint in regard to pneumatic truck tires, aside from their high initial cost, is that they are subject to injuries, cuts and damage, generally of such a nature that they cannot be repaired except at the factory where they were made or, in a few cities, at a factory branch; often they are damaged beyond repair. This is not only expensive but frequently necessitates the purchase of more than one set of spare tires should the first set be injured while the others are being repaired. A tire of 7-in. section or larger, if run flat, is likely to be ruined beyond repair. In more than a dozen cities operators have said that the principal cost of punctures or blowouts is caused by the necessity of laying up trucks awaiting new tires due to stock shortage, or on account of sending the damaged tires to the nearest factory branch for repair. While repair-mold equipment has been ordered for large-section tires, the heavy demand on the part of the tire factories for new molds of all sizes and the difficulty of producing them has made deliveries very slow.

In nearly every city the large tubes can be repaired locally, but the casings have to be shipped away, the truck operator paying either freight or express charges in both directions. Moreover, it is frequently reported that repaired casings deliver but small mileage due to the over-cure of the joined portions. This danger is more difficult to overcome in large-section tires, due to the longer cure required to vulcanize the interior portions of the new part of the casing. No doubt this feature will ultimately be corrected. The tread seems to give less trouble than the side walls, which are more susceptible to rut wear and overloading abuse.

Because so few service stations are as yet equipped to handle repairs on heavy-duty tires, dependable cost figures are not at present available. In fact, where stocks are available "adjustment" exchanges have usually been made instead of repairs. Of all the causes of dissatisfaction reported for changing back to solid after using pneumatic tires, the most numerous have been those brought about by the delays and expense incident to their repair, including additional spare-tire cost and truck hire while waiting for the return of the damaged tires. Such disadvantages are inevitable in a new development such as the one under discussion but, so far as imperfect service features are concerned, they are being overcome as rapidly as possible. In the meantime, truck engineers, salesmen and operators should not condemn the movement toward the use of pneumatic tires, for undoubtedly it will be the means of increasing the scope of usefulness of motor transportation.

Having thus reviewed the advantages claimed for pneumatic tires on trucks in the debatable field and having specified some of their relative disadvantages, I can say that, in my judgment, the question is too new to be decided theoretically or from such meagre records as are now available.

Specific Considerations

What general conclusions will guide the operator in the selection of the most satisfactory and economical equipment for his particular installation? So far as I know none have been formulated and given publicity. In this connection, however, I suggest that, in the present state of development, the field for each type of tire may be separated into three classifications, within one of which the operator can reasonably locate his requirements and decide upon his equipment. These three groups are

(1) The imperative field
(2) The economic field
(3) The optional field

The factors that would bring a truck within the first classification for solid tires are (*a*) If it travels over pavements not necessarily good, but having a reasonably hard road surface to provide traction; (*b*) if the delivery must positively reach its destination without fail, at a promised time; (*c*) if the delivery must be made regularly on a given schedule in which the regularity is a more important factor than either speed or cost of delivery, and (*d*) if it carries heavy loads with frequent overloads beyond the rated capacity of the tires.

Similarly the factors that would bring a truck within the imperative field for pneumatic tires are some combination of the following: (*a*) If it travels over surfaces on which traction cannot be obtained by solid tires, and when the need for traction is such as to outweigh the item of cost; (*b*) if the need for speed of delivery is more important than its cost, and (*c*) if the merchandise carried is so perishable or fragile that it must be protected from road shocks, even at high cost.

The factors that would bring a truck within the economic field for solid tires are (*a*) Short hauls in cities where speed is relatively unimportant, (*b*) heavy loads with a tendency to overload, (*c*) traffic congestion which reduces average speed, (*d*) loading and unloading delays and (*e*) need for low delivery cost.

Similarly the factors that would bring a truck within the economic field for pneumatic tires are (*a*) Road conditions which will not prematurely destroy the tires, (*b*) long hauls, (*c*) high average speed, (*d*) relatively light loads with no overloads, (*e*) good tire-service conditions and (*f*) low cost subordinated to quick service.

In analyzing the economic field, the operator must first decide whether or not he can avail himself of the potential speed pneumatic tires would give. This, of course, includes possible delays due to tire trouble as a result of bad road conditions and provided the local tire-service conditions cannot be depended upon. Next, the features of his service provided by pneumatic tires must justify their extra cost.

The distinction between the economic and the optional fields is difficult to make. In fact, the decision as to which is the better equipment may be purely a matter of personal opinion, without strong factors on either side. Hence I shall not attempt to define them.

One of the most interesting and significant developments which I have noticed is the growing tendency among truck operators to use pneumatic tires on front wheels where the need for protection from vibration is the greatest and solid tires on the rear to carry the burden of the load. This practice has much to commend it, and should steadily grow in favor. Another tendency is toward the use of some type of cushion or non-rigid wheel which, although equipped with solid tires, provides extra resilience through their peculiar construction. There seems to be a very large field in which such wheels can be used both economically and advantageously from the standpoint of improved service.

Designing engineers should study to develop cushioning effects that may be possible through other means than tires, such as cushion wheels, improved springs, shock absorbers and the like. While no mechanical device is so resilient as air, much progress must be made before the difficulties are overcome of making air serve acceptably in puncture and fool-proof rubber tires, although the industry is making notable improvement in this direction. Finally, all truck operators should keep account of costs, so that intelligent comparisons may be made. In my judgment, the easiest and most effective way to do this so that all records may be readily comparable, is to use the National Standard Truck-Cost System. Thus, if they select tire equipment after a careful analysis of the peculiar conditions surrounding their problems and keep careful and accurate records of operating costs, they can reasonably expect to eliminate many of the annoying uncertainties of their delivery systems and place their tire installations upon a really scientific basis.

NEW ENGINEERING INSTRUCTION PLAN

DURING the past thirty years or more the normal curriculum of the American school of engineering has changed very slightly. Its object has been to train the men who design and operate our industrial plants, transportation systems and public utilities. That it has been successful in this aim is amply evidenced by the giant strides with which our industries have advanced during that period.

The graduate of the engineering schools has nevertheless been open to general criticism and with justice. He has been trained to deal with things inanimate and with them only; he has not learned to consider man. As a consequence he has not taken those higher administrative positions in industrial enterprises to which his technical knowledge should entitle him but has remained generally a technical subordinate. This condition was not so marked twenty years ago as it is today. In this interval individual industrial organizations have grown vastly in size and this country has developed into the greatest manufacturing community in the world. At the same time a new and highly scientific technique of industrial management has been developed and there has arisen the present complex labor situation.

The fundamental problem before the industrial executive at the present day is the selection and making of a special product in his factory, and this is in most cases an engineering problem. It is becoming increasingly important that the executive should have a sound knowledge of engineering sciences as well as a thorough knowledge of men and of business. Very little attempt has been made to meet the need for technically trained industrial executives. A number of schools have instituted four-year courses in engineering administration and have substituted for courses in the engineering curriculum various other courses in accounting, business administration, industrial management and allied subjects, but this has resulted usually in a weakening of the technical courses without much appreciable gain elsewhere.

The best results that have been obtained so far in training engineering executives have been through a system of cooperation with the industries whereby the students have alternated between their college studies and supervised work in industrial establishments, either throughout their whole undergraduate career or for a part of it. The pioneer work in this direction has been carried out at the University of Cincinnati under the brilliant leadership of Dean Schneider and has also been developed at the University of Pittsburgh under Dean Bishop.

The four years commonly provided for an undergraduate engineering course, should not be reduced, so that the additional time necessary if the course is to be extended by the inclusion of experience in industrial establishments must be obtained either by increasing the length of the course or by utilizing the summer vacations. Many engineering students have always found employment in industrial establishments during the summer vacations, but as this work is not adapted to the special needs of the student and is not supervised, it is of comparatively little experimental value.

The Harvard Engineering School will inaugurate next June a new plan of engineering training including cooperation with the industries. The first two years of the program are substantially as in other schools, except that there is no differentiation between mechanical, civil and electrical engineers and that the students are not segregated either in their classes or in their social relations from the undergraduates in Harvard College and thereby escape the narrowing influence of an exclusive association with other engineering students. They must take certain courses in mathematics and in pure science, but have the opportunity of obtaining as broad an education as college students of their class. The work of the senior year is also carried out along the usual lines.

The combined engineering study and work in the industries starts in June of the sophomore year and lasts until the October at the beginning of the senior year. During the sixteen months the class is divided into two equal sections, which alternate from study to industrial experience at two-month intervals, with one vacation period for which the ambitious student may substitute industrial work. Those students who take the regular offering get eight months of study, which is the actual study time at present, and six months of experience in the industries; those who so desire may have eight months in the industries. There will be a continuous supply of students to the industries and continuous instruction in the school. Courses given within this period will have to be duplicated.

The scheme outlined above is optional, but the present indications are that it will be elected by practically all students in the school. It adapts itself well to graduates in arts or sciences from Harvard or other colleges who enter the third year of the engineering school, even if they enter in August or as late as October.

The cooperation with the industries will be under a director who will arrange with the industries for placing the students at such work as will give them the best opportunities for experience. The students will receive the same pay as other workmen doing similar work and will be treated by the industries like other workmen except that the director of cooperation will have freedom of access to each student at any time and will be permitted to arrange the general character of his work. The director will meet groups of the students in the evenings during their industrial period to discuss with them their problems and experience. Each student will be given a syllabus of questions relating to the type of work which he is doing, the answering of which will require him to observe closely, not only the technical processes which he himself is carrying out, but also the whole system of management of the factory and such general technical details as he may have opportunity to observe. The syllabus will also require him to apply to his observations that body of engineering theory which he has acquired during his studies.—Lionel S. Marks in *The Evening Post* (New York.)

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Automobile Body Design

By WILLIAM BREWSTER[1] (*Non-Member*)

ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS

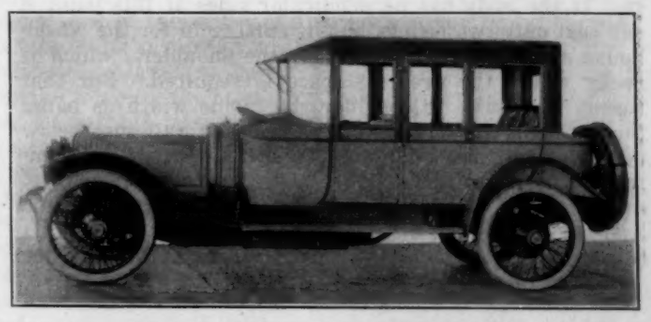
AN automobile body must be considered from two different viewpoints, its suitability for the work required of it and its appeal to the eye. All designs should first be based upon practical needs and construction. The first consideration should be the number of passengers to be carried and the way in which they are to be arranged; in other words, the style and arrangement of the seats. These factors determine, or should determine, the length and width. The wheelbase is a controlling factor in respect to length, and affects length in two ways.

The position of the rear axle governs the position of the rear kick-up in the chassis frame; this, to a large extent, determines the position of the rear seat. If this seat is put too far to the rear it is impossible to provide a flat floor directly in front of it, due to interference with the kick-up of the chassis frame, and unless a flat floor is provided it is impossible to sit with one's feet in a natural position, thus detracting from the comfort of the car. It may also bring about an added defect by causing the rear seat to overhang the rear axle to such an extent as to cause bad weight distribution and thus produce bad riding qualities.

The position of the rear wheels also determines a very important dimension, that of the distance from the back of the front seat to a point where the curve of the rear fender cuts across the top edge of the chassis frame. The doorway is essentially to make the body easy of access. If the curve of the rear fender comes far enough forward to require cutting into the bottom of the door, then the space at the bottom of the doorway, for entrance, is curtailed to such an extent that sometimes only agile persons can use it conveniently. Further, a cut in the door at this position can in some cases prevent the lowering of the door window to be flush with the framework of the body, which is generally desired and absolutely essential on any landaulet. Realization of this fact has frequently resulted in the front compartment being unduly restricted, causing discomfort for the driver. The increasing popularity of the closed body is probably having an effect on chassis engineering, because it is noticeable that there is much less space wasted under hoods than formerly. Opinions will of course differ as to the exact amount of space which should be given, but the position of the driver is really controlled by dimensions that are determined entirely by chassis construction and to which the designer of the coach work is obliged to conform.

First, the driver must sit so that the pedals can be operated without strain. This really determines the position of the driver's seat. The steering-wheel should come where it is convenient for the hands to reach it. A very common fault is that the steering post is too short so that it comes where a tall man's thighs will strike it, while if the bottom of the wheel comes in line with the joint of his body with his thighs, almost any size of person can be made comfortable without taking up undue space behind the wheel. The rim of the wheel nearest the driver, on an ordinary upright post measuring about 25 in. from the bottom of the steering wheel to the top of the chassis frame, should be about 27 in. from the pedals. A comfortable distance should then be allowed behind the post to the front framework of the seat back, allowing for the upholstery. This dimension on a limousine body is about 19 in. The horizontal distance from the lower edge of the steering-wheel rim to a vertical plane tangent to the front of the rear-wheel tires, should be about 48 in. on any closed car. Of course, more room gives more latitude in design. An open car body can be made very satisfactory with 6 in. less.

A rather important consideration in the case of a closed car is the point at which to measure the height. The measurement should be taken where change in design would have the least effect. For instance, if a body were measured in the center and there were a large curve to the roof, one might consider that the measurement would be ample; yet a person sitting in the corner might be cramped for headroom on account of the curving down of the top at the sides. To be safe, it is wise to measure about 8 in. in from the side wall, which would be about the center of the head of the passenger sitting at the outer end of the seat. A body intended for general use by people of all ages requires a reasonably high roof. Elderly people require more headroom when entering a car and do not as a rule like very low seats. A family car generally has the extra seats in fairly frequent use and requires the seats to face forward, necessitating a large body. These seats force a person to sit fairly upright and the roof should be high enough to allow a person of average height to wear a hat and sit in a natural position. A family car is also owned as a means of comfortable transportation, and its appearance should suggest its character.



THE 1910 WINDSHIELD IN WHICH THE PILLAR IN FRONT OF THE DOOR IS BROUGHT BACK AND A VERY LIGHT METAL CONSTRUCTION IS USED IN FRONT TO REDUCE THE OBSTRUCTION OF THE DRIVER'S VISION TO A MINIMUM

This immediately brings out the fact that to be truly artistic nothing should look crowded. The design should

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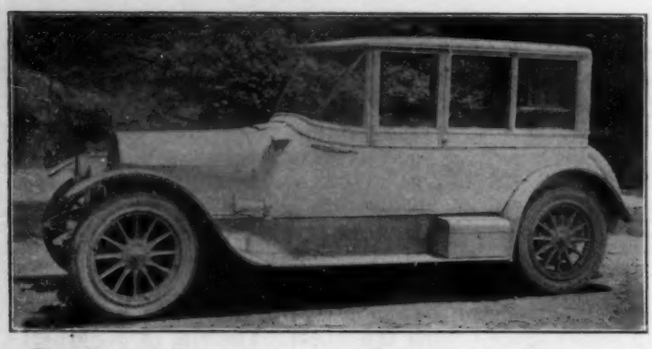
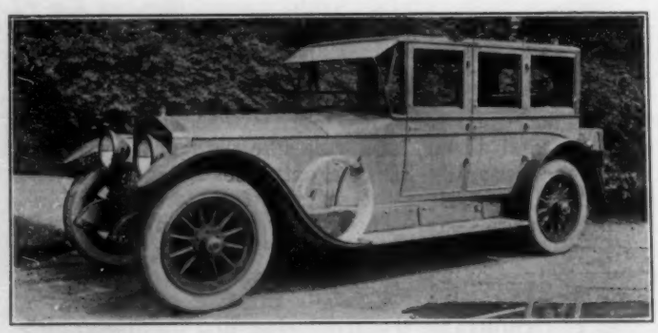


THE 1912 FORM IN WHICH THE WINDSHIELD IS SLANTED TO ELIMINATE REFLECTION

show that there is a place designed for everything to be carried. A low total height from the ground to the top of the roof is always desirable, but the obtaining of this characteristic is a matter for the chassis engineer. The body itself must be of a certain height irrespective of the chassis and if the chassis hangs high it is impossible to obtain a pleasing effect. The minimum distance from the floor to the roof of a family car should be from 53 to 55 in. The enclosed-drive or sedan type is chosen often by an owner who wishes to drive the car himself. Such an owner is apt to be willing to sacrifice a little headroom in order to give the car a greater suggestion of speed or smartness, so that the headroom can often be cut down 2 or 3 in., but if brought down below 50 in. the car is rather awkward of entrance.

Another important and fundamental dimension is the width of the rear seat, and by this is meant the width of the framework of the body on a level with the passenger's shoulders. Most cars require about the same clearance between the rear wheels and the wheelhouse. If the cushion is kept reasonably low, the top of the cushion will be determined by the distance between the inside of the wheelhouses and this will be only about 44 in. If the body has perpendicular sides at this point it can seat only two people, but by cutting in for the wheelhouse more room is allowed for the shoulders, which is really where the greatest space is required. For that reason it is wise to consider the inside width as being that between the framework of the belt rail just below the bottom of the windows. To seat three persons comfortably requires about 54 in., but 2 and sometimes 3 in. can be cut off and still be satisfactory for slight people. Another point that is frequently lost sight of in this respect is the shape of the body. When the body is flat at the side and has round corners the distance between the rear-door pillars, at the belt-rail height, is a very good measurement to use in comparing bodies, but when the body has a square corner it is almost invariably tapered toward the rear; hence this measurement would be misleading as the passengers sit 7 or 8 in. from the rear. The measurement to be exact should be taken close to this spot. These rules have been mainly discovered by experience. It is easier to apply a comfortable body to a modern than to an old-style chassis, on account of the developments in the chassis which is now lower and has a longer wheelbase.



THE LATEST FORM OF WINDSHIELD DEVELOPED IN 1917 IN WHICH THE BOTTOM PORTION IS SLANTED IN THE REVERSE DIRECTION TO REDUCE THE AMOUNT OF RAIN WHICH ENTERS WHEN THE WINDSHIELD IS OPEN

WINDSHIELD EVOLUTION

One of the most interesting effects of criticism is the evolution of the windshield. Originally it was perfectly plain and perpendicular without a break of any kind. This gave protection from the wind, but it was found that when wet with rain or snow, the windshield could not be seen through. The windshield was then cut in half, the upper part swinging forward, thus allowing a clear vision in bad weather. But it was still found that the perpendicular windshield reflected objects in the rear, so that at dusk the driver might occasionally be deceived by the reflection of a person already past and apply the brakes suddenly to avoid running over someone. The development then was to slant the windshield, causing the reflection to drop to the driver's feet. On enclosed cars the development was a little different. Originally, the front frame or pillar interfered very seriously with the driver's vision when he had to turn even a little from a direct straight line, so that accidents often occurred from this cause. To overcome this the front pillar of the body was brought back some 6 or 8 in., to a point on a line with the front of the driver's cushion, and a metal strip only sufficiently wide to hold the glass was brought out in front to keep the required room inside. This windshield was originally made straight and then, with the evolution of the tilted type, it was slanted back to meet the front pillar at the top. This is the general method of making windshields today, with the top half folding outward in case of snow or storm. It was found, however, that with the upper half of the windshield out and the top of its bottom half slanting inward to the body, it caught the rain or snow which come into the body when driving in a storm. To overcome this the bottom of the windshield is now slanted in the opposite direction; that is, the bottom is slanted inward a little so that when the upper part is open, the rain or snow strikes this reverse slanted glass and falls on the cowl.

As a commentary upon how ideas regarding what is beautiful or satisfactory in design are modified by an understanding of proper construction, many people at first objected to the slanting windshield solely because of its appearance, but no one will take a straight windshield now, when the matter of looks is considered, because their eyes have become accustomed to the change. Another transition of what appeals to the eye is now in progress with the new windshield last described. Many people objected to this innovation at first but, after studying it and seeing the reason for it, they prefer it to the plain single slant and see beauty in it.

STRUCTURAL AND ARTISTIC CHANGES

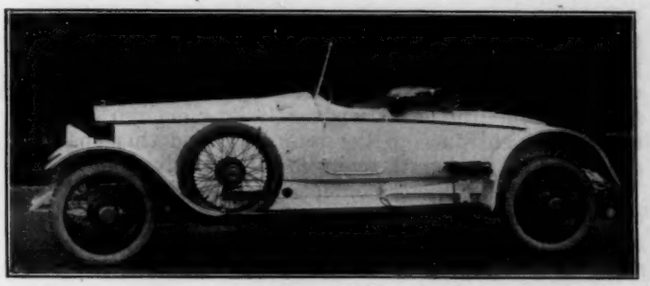
A structural change is often made at the expense of something known to be good. It is then necessary to

decide whether the change is more advantageous than what must be sacrificed. This is illustrated when the front pillar is brought back. It is then more difficult to enter the front seat because the corner of the cushion must be cut to allow foot room and a person cannot walk into the seat as when the pillar is the full distance ahead; but it is perfectly easy to get in and out if it is done intelligently. A few seconds of possible slight inconvenience are then sacrificed for hours of probable comfort in driving.

We have now given consideration to the size and relative position of the seats and doors. We have also determined the height of the roof above the floor, that of the floor above the ground being fixed by the chassis. The next step is to design the outside of the body, the wings, etc. Art is simply beautifying the practical. A box with doors and windows built upon a chassis would accomplish a purpose but it would not be artistic; hence it is necessary to determine what parts can be made more delicate and less clumsy. We require less room for our feet than we do for our shoulders, so the body is invariably made narrower at the bottom than at the top. On a large body the square corners at the rear give way to the round, as that space is not necessary inside the body and round corners tend to make the car look smaller. For the same reason a small car is often made with square corners to give it more character, but the square corner in rear view on a wide car is most ungainly.

The size of the windows is generally a matter of individual taste or fashion and is affected by what is generally termed the belt rail. This is that portion of the body, running horizontally, which marks the division between the lower panels of the body and the upper. If high it gives the appearance of bulk and heaviness. If too low it seems out of proportion because of giving too much glass. A moderately low belt rail tends to make the body look more delicate, and anything in moderation is less apt to go out of style quickly. Most present-day cars have the driver's part enclosed by doors, either low as in an open touring car or fully enclosed. This front part of the car is generally of one surface with the hood and cowl and often continues without a break completely around the body.

Moldings are added to break up large surfaces. They make panels which allow the car to be painted in different colors. A body having no moldings of any kind would have to be painted in one single color as there would be no place to make a change. If it is desired to break a large plain surface, as on a limousine body, a nearly perpendicular molding is generally added in front of the rear door. This is called the coupe pillar. It divides the owner's part of the car from that of the chauffeur and allows the rear of the car to be painted in a different color from the front. This is perfectly good form for a car which a chauffeur drives, as it differentiates the owner's from the servant's portion of the car. For that reason it is not so advisable on a car that the owner drives, such as a phaeton or enclosed drive type. The molding or pillar referred to is absolutely necessary, for instance where imitation cane work is applied, as otherwise there would be no place to stop it. It is the first molding that is applied vertically. The most important horizontal molding is the belt rail. All moldings tend to shorten or lessen the width of the panel in which they are placed, so that marking the belt rail tends to make the car appear lower to the eye. For that reason two moldings some inches apart, forming what is called a



THE ORIGINAL CONCEPTION OF CONTINUING THE SQUARE LINE OF THE BONNET THROUGH TO THE REAR LOWER END OF THE BODY

double belt, are employed. This lightens the bottom panel, allowing the belt rail to come lower down, so that the lower panel does not loom so large. This tends to lighten or make the design more delicate. The double belt is practically a continuation of the old crest panels used in carriage days for generations past, on which armorial bearings of the family were placed. These and all other moldings must be placed with great care. They should always be continuous and at least should not end abruptly, as if there were no reason for their existence. The moldings form panels and if the panels are not entirely enclosed trouble in the painting results. One color will then run into another and show at once to the critical eye that the design was not thoroughly worked out. Moldings are often applied to hide the joints of construction, but the same ideas and principles should prevail, that the design must conform with the construction as if done for a purpose and not left to chance; in fact, construction must always be the basis of the design. We construct first and then endeavor to give that construction an artistic effect.

A detail of interior finish or design which is especially adaptable for touring work, where serviceability and cleanliness are important, involves finishing the upper part of the car in its natural construction showing the framework of the body and the bows of the roof. These can easily be varnished or painted to harmonize with the upholstery. Then we have only to stretch the covering for the top over the bows, first putting on a lining which can be painted to match the woodwork. There is practically no wear to this finish, if done well.

Of course, any body cannot be put upon any chassis indiscriminately. A low rakish sort of body requires a correspondingly low slant to the steering post and more space for the driver, for, when we lower the post, it must be made longer as the driver's legs become straighter and need more room. Conversely, a low body cannot be put upon a chassis with a high steering post, as the

ANOTHER EXAMPLE OF THE SQUARE LINE OF THE BONNET BEING CONTINUED AROUND THE UPPER PART OF THE BODY IN A SINGLE CONTINUOUS LINE, THUS MAKING A DOUBLE BELT

driver must then sit high to be in a proper position for the wheel. In this position a seat would be out of proportion to the rear of the body. A low steering post with a low body is difficult to use successfully with a family car, as the chassis is rarely long enough to allow the proper entrance to the rear door and this space is shortened by the length required for the driver.

It would seem almost obvious that for the best interests of the users of a car it is wise to have as little waste space as possible in the center. It is like the space amidships on a steamer; the center of the chassis is the most comfortable part for riding. Yet open cars are often designed with a second little cowl back of the chauffeur and the space under the cowl is used for cabinets for the storage of small articles, thus giving up the most valuable space in the car for storage. Furthermore, this cowl cuts into the entrance, often requiring a large cut in the bottom of the door, so that it can hardly be called good design. If any storage space is wanted the body can extend a few inches behind the rear seat, making a pocket in the least desirable part of the car.

It is generally good practice to make the car appear as low to the ground as possible and the roof line, of course, bears directly upon this. Keeping the windows as high as the construction of the body will allow tends to make a very light-looking roof and gives the maximum outlook from the interior, but one also sees at once the entire height of the car. If the windows are lowered 2 or 3 in. from the top and the line of the roof rounded over, the car will appear lower although, of course, not as light-looking in this detail. This treatment is therefore perfectly legitimate if this effect is desired.

The position of the extra tires does not materially affect the design, but for touring it is rather impractical to hang them in the rear as that space is needed for the trunk rack to carry luggage. It is therefore wise to carry tires in the wings at each side of the dash. They are also much cleaner to handle if tires have to be changed en route, but for very small light cars, such as runabouts, they must be carried in the rear to give the weight required for traction at the rear of the car.

The design of wings or fenders bears to a certain extent upon the completed design, and here again there has been certain evolution. In early cars the front wings had the outside front end much higher than the inside, instead of being parallel with the ground. This, however, allowed the mud and dirt to be deflected from the wings at such an angle that the wind would drive it into the car; this type was therefore superseded by the present type of wing, which is always kept as close to the wheel as possible. Flanges are also added at the sides of the wings for the same reason, as an additional protection. A slightly rounded wing with flanges gives a delicate light appearance and is desirable with a light-appearing body, but there is a large dome-shaped fender without angle of any kind which is eminently practical although not very delicate in appearance. It can be used with good effect on a heavy type of body, but there would be a question whether or not they are in keeping with a delicate design. For a strictly fashionable town car, wings are often made on the type of the old horse-drawn Victoria, that is, a light metal frame covered with leather. This gives a very handsome effect and shows at once that the car is not for touring. It also conveys the idea that the owner is critical and wants his car, like his clothes, for different purposes. Instead of using the almost universal running-board the wings can be made separately with only a step to the rear entrance, and an extra wing brought up from the front of the rear step exactly as in the old Victoria. This naturally does not give the whole car as good protection as does the running-board, but it tends to make the car look shorter and higher and is liked by many as a still further evidence that the car is for town use. However, if used in this way, the wings should be of leather.

While discussing town cars, another detail of the treatment of the chauffeur's part should be mentioned. When leather wings are used, the usual type of fore-doors need not be used. This allows the liveries of the chauffeur and footman to be seen and tends to brighten up the effect, thus differeniating the town from the touring type. For extremely cold weather a light metal frame covered with leather can be used for a temporary door, but as this is only to be temporary for the cold months it should not be a part of the design; this shows that it is exactly as intended, a temporary protection from the weather.

Influence of Weight Upon Design

The question of weight bears only indirectly upon design, as weight is largely determined by the type of construction. As the designers of the chassis use every possible endeavor to save even a few pounds here and there, it should naturally be the duty of the body designer to try and make his part of the car as light as possible, but there is a limit to what can be done here on account of having to consider doors and other parts which require substantial construction in order to work perfectly. Naturally, a door must be set in a frame so firmly that it will not spring and bind the door, making it ineffective. Not only must the door frame be rigid, but every part of the door itself must be made stiff enough that it will not rattle. In fact, having everything work smoothly so that it will not rattle, differentiates the car body from the airplane where noises and relative flexibility are matters of small moment. Hence, lessons gained from airplane construction are practically useless to the coach builder.

The glass used in a closed car is probably the heaviest single part. Few laymen appreciate the fact that the ordinary glass used behind the chauffeur weighs about 20 lb., for a thick plate glass has to be used to get one of sufficient clearness. This heavy glass necessitates correspondingly wide runs or grooves in the pillars, which determine the size of the pillars. While the latter might be made lighter so far as strength is concerned, a certain amount of bulk is necessary on account of the glass runs.

There is no construction so light as that employed in the old wooden carriage, and nothing gives as fine a surface when finished, if well made. The white-wood panel used in old coach building was some 10 per cent lighter than the aluminum panel used today so that, all things being equal, a wooden body is about 10 per cent lighter than the corresponding aluminum-covered body. However, aluminum is now used almost entirely for two reasons. It gives more latitude in design. For instance, it is much easier to make large round corners in aluminum than in wood. Also, the paint will stand better against the "working" of an automobile. The twists and turns a car gets over very bad roads or bumpy snow, especially when it is cold, seem to crack any paint on wood panels while the aluminum stands this very much better. Cast aluminum panels are sometimes used, but they are very much heavier.

In conclusion, the highest type of automobile body designing should always be based primarily upon a high degree of practicability.

National Balloon Race

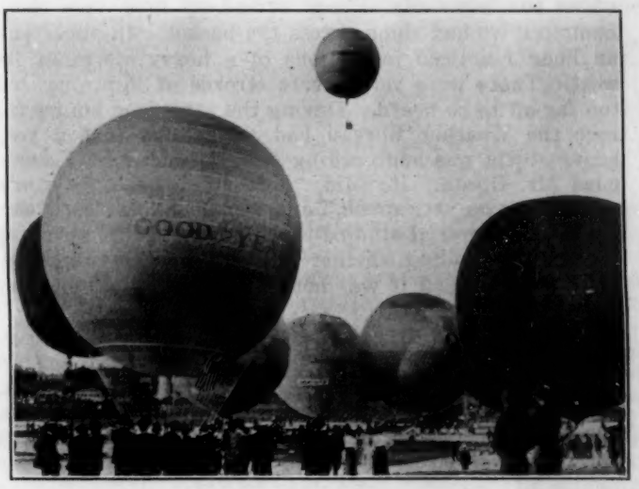
By W. T. Van Orman[1] (*Non-Member*)

Mid-West Section Address *Illustrated with* Photographs

I BELIEVE that Mr. Upson's reputation as a balloonist is not equalled anywhere in the world. He is the present holder of the Gordon Bennett trophy which he won in 1913. It is interesting to study the way in which Mr. Upson won the International Balloon Race from Paris. He started against a field of balloonists who had had years of experience. He was comparatively a novice, but firmly believed that by scientific study he would be able to compete successfully. The result was that Mr. Upson and his aide, R. A. D. Preston, landed near the Humber River in England, while the other balloonists landed on the coast near the Peninsula of Brest. He won the race through his belief that he could select the proper currents, after drifting out over the Atlantic Ocean, to carry him back to England.

I was aide to Mr. Upson in the National Balloon Race that was started at St. Louis in October, 1919. Ten balloons were entered. They were all filled with coal gas, a product of the coke ovens. This gas has a "lift" of probably 4 lb. per 1000 cu. ft., whereas hydrogen, which I have been accustomed to use, has a lift of 70 lb. To obtain sufficient lift, the balloons must have a capacity of 80,000 cu. ft., which means a diameter of 50 ft. The balloons are spherical in shape, and have an appendix or safety valve at the bottom to permit reduction of any excess pressure on the interior of the balloon.

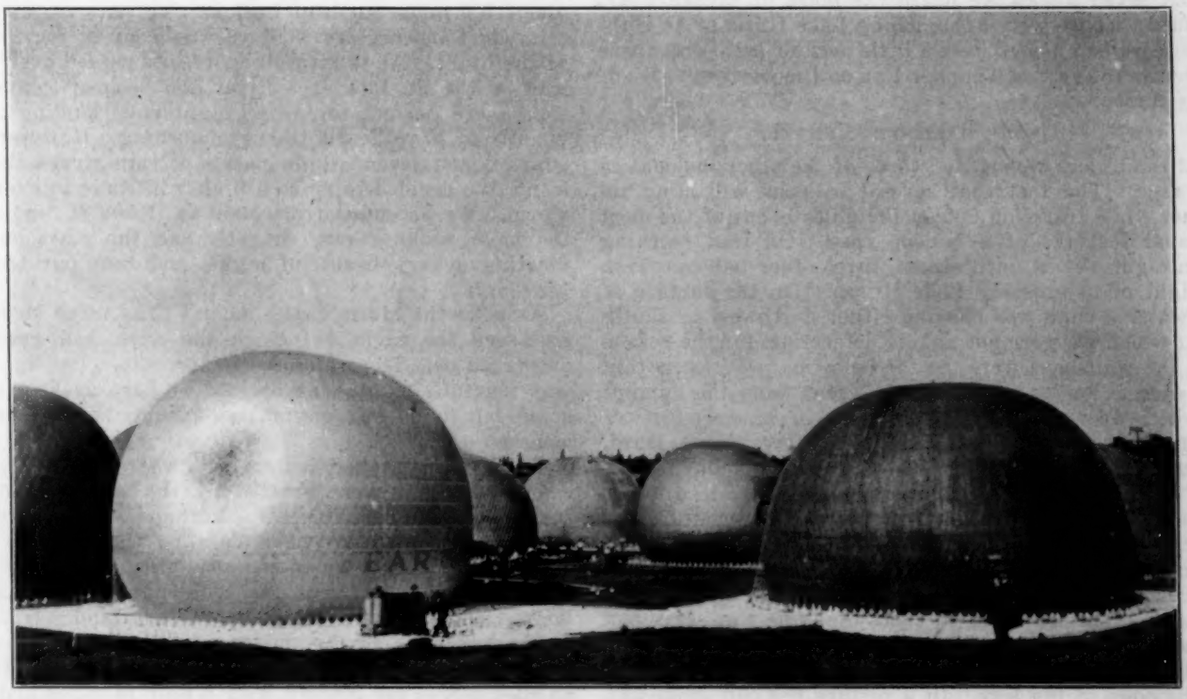
[1]Aeronautical department, Goodyear Tire & Rubber Co., Akron, Ohio.



Ascension of the Pilot Balloon

The Start

We drew third position. The first position is considered the most unfavorable, as its pilot does not have an opportunity to study the air currents or the direction in which the other balloons leave the ground. Last place is, of course, very desirable. We left the ground promptly



Inflating the Balloons Preparatory to the Start of the National Balloon Race at St. Louis, Oct. 1, 1919

at 6:15 in the evening and floated northward over St. Louis. About seven o'clock we had passed over the Mississippi River at Alton, Ill. Then it commenced to grow dark rapidly. At eight o'clock the moon came out. We were able to see the Northern Lights very distinctly, one of the most beautiful sights I have ever seen. They were fan-shaped, changing from dark red to brilliant white. They lasted until 10:30.

At eleven o'clock we decided that it was time for one of us to sleep. Mr. Upson curled up in a very short hammock we had slung across the basket. In about half an hour I noticed indications of a heavy storm in the west. There were very severe strokes of lightning, but too far off to be heard. During the afternoon before the race the Weather Bureau had warned us that a very heavy storm was approaching from Minnesota. I awakened Mr. Upson. He said, "I do not believe the storm will bother us very much," and went back to sleep, leaving me to worry. I studied the storm carefully, watching the stars and noting whether it was approaching or receding. Finding that it was not gaining on us, I felt very comfortable.

At about 12:30 we passed over Peoria, Ill. We recognized the town from the fact that it is alongside the river. At this time we were sailing at an altitude of 2000 ft. The conditions were what are termed "stable," that is, the air had reached a temperature gradient such that the balloon did not rise or fall but sailed along at the altitude mentioned.

About half past one Mr. Upson decided he had slept long enough and I turned in. I awoke about four o'clock to hear a very dismal sound below me. We had been over Lake Michigan for two hours. I saw water. We were crossing the lake ahead of the storm.

About 4:30 the next morning we sighted the shore. We were traveling at that time at the rate of probably 40 m.p.h., and did not learn exactly where we were. We crossed the State of Michigan which appeared to be sand hills and trees, there being very few holes in the clouds. About seven o'clock we heard the noise of breakers and decided that we were approaching Lake Huron. At eight o'clock we had passed over a little neck of land which was evidently the arm of Thunder Bay on the western shore of Lake Huron.

Other Balloons Sighted

At ten o'clock we sighted three of the other balloons in the race. The fact that several balloons will cling together while traveling 600 or 700 miles is one of the most unusual features of a balloon race. On that morning from eight o'clock until eleven, three other balloons were in sight of us crossing Lake Huron. On the surface of the water a wind was blowing either northwest or southeast; which we were not able to determine, for the reason that the whitecaps were too far below us. We knew that the wind below us was much different from the current in which we were traveling.

At about eleven o'clock we passed over Cape Hurd, which lies between Lake Huron and Georgian Bay, sighting land for the first time that morning since eight o'clock. The land looked inviting to us. Riding for three hours over a lake in a balloon is not very exciting, and the melancholy noise of the waves is rather monotonous.

The northern shore of Lake Huron is a cliff 50 or 60 ft. high. The water is so clear that one can see down below the edge of this cliff probably 25 or 30 ft. It certainly is an impressive sight to see this very abrupt cliff on the edge of the lake. In a picture the cliff looks like the crest of a very small wave.

From about twelve o'clock until half past one we were passing over Georgian Bay proper. We continued to ascend until we reached a maximum altitude of 13,000 ft. The sun came out and the sky was extremely blue at that altitude.

One of the amusing incidents of the race was that when we started out from St. Louis the appendix of the balloon was tied shut with a small breakable cord. We started out with the idea of keeping the appendix closed, keeping the pressure in the bag within the working limits. Before the race I asked Mr. Upson what he considered the safe pressure for the bag. He told me 50 mm. of water, or 2 in. of water pressure. In passing over Georgian Bay, I crawled into the hammock for a little sleep, knowing we were going up and up. Mr. Upson allowed the pressure to reach 40 mm. of water. I had misunderstood that the bursting pressure was 50 mm. I knew he was standing with the valve cord in his hand, allowing the pressure to go up. I expected the balloon to burst every minute, although I had full confidence in him. I had just fallen half asleep, when there was a rip and roar, which sounded as if the balloon had burst. There was a rush of gas and the tearing of fabric. I looked wildly up only to find that the string which held the appendix shut had broken as a result of the pressure and allowed the appendix to flop open, a little gas consequently escaping, and there being a rustling noise of fabric.

From Georgian Bay we passed into the northern wilderness of Ontario. There is nothing but lakes and trees and little streams there. It would take a man at least three or four days to get out of that section if he ever happened to land there. According to our maps there was only one railroad across a stretch of 400 miles.

Sailing in a Storm

About four o'clock in the afternoon we decided to come down, since we knew that would probably be our last chance to check our location before it became dark. We found that we were passing over Athens, Ont., which is about 100 miles north of Buffalo. We threw over a few telegrams and decided that we would go on for the rest of the night. At seven o'clock we had passed over Cornwall on the St. Lawrence River and decided that conditions were perfect for an all-night ride, landing in the vicinity of Nova Scotia the next morning. However, at a quarter past seven a light patter of rain struck the balloon. We decided to go to a higher altitude to avoid the storm. We ascended from 3000 to 10,000 ft. and found the moon shining very brightly and the stars out, indicating a very beautiful night, and that our troubles were over.

At 8:30 the storm broke on us. The same storm we had seen the night before in the west, had gradually overtaken us. The water fell in torrents. The lightning was fearfully close. We decided to fight as long as we could, but found we were making a losing fight. The rain weighed us down.

We decided we had better land where we could. We came down and were greeted by the same melancholy sound we heard over the lake. Perhaps we were over the Atlantic Ocean, Lake Champlain or the St. Lawrence River. We came down in some timidity. The most welcome sight we saw was the little lights of the farmhouses, showing we were still over dry land. We came down very close to the top of a very large wood some 4 or 5 miles long. The indications were that there were no open places for landing within 5 or 10 miles and that we might have to land in this woods. We decided to stay

up above the trees as long as we could to find an opening. As we sailed over the top of the trees we noticed a road ahead of us during a flash of lightning. We then knew we were somewhere near civilization, and decided to land near the road. We swung down, holding the flashlights over the side of the basket to see what we were approaching. The roof of a barn came up to meet us. The moment we struck it I pulled the rip panel, which releases the gas from the bag quickly, and we bounced over the roof. The moment the basket touched the ground, we searched for a place to sleep.

The farmers in the vicinity seemed frightened at our story. We had to walk over 2 miles in the rain to the town of Stanbridge, East Quebec, where the proprietor of a hotel kindly put us up.

The result of the race was, as we found out later, that we had won, covering a distance of about 1045 miles in 27 hr. We were after the American record of 1174 miles held by Alan R. Hawley and Augustus Post, but considering that the storm had driven us down, we felt well satisfied to think we had made a safe landing and won the race.

PROPAGATION OF LONG ELECTROMAGNETIC WAVES[1]

A STUDY has been made of the properties of an extremely long-wave direction-finder coil, with a view to determining the feasibility of using such long-wave direction finders on large aircraft on long flights, such as, for instance, a transatlantic flight. The use of direction finders for aircraft having been carried to such a very satisfactory conclusion at the Naval Air Station, Hampton Roads, Va., on a wave length of 2500 m., it seemed highly desirable to ascertain if it might be possible to utilize for airplane direction-finder work existing high-power stations in Europe in case of extremely long flights. Since all of the transatlantic stations which can be considered to be really high-power stations operate on continuous waves of lengths between 8000 and 20,000 m., it was decided to build a direction-finder coil at the Naval Aircraft Radio Laboratory of the Bureau of Standards, of suitable dimensions for installation in a type F-5-L, H-16, or NC flying boat.

In the process of this study, comparison was made of the relative accuracy of settings obtainable with the two-coil maximum and the usual single-coil minimum methods. It was noticed that there were very considerable variations in the apparent bearing of the Naval Radio Station at New Brunswick, N. J., transmitting on 13,600 m., and a series of observations was undertaken with a view to determining whether these apparent variations of bearing were of local origin or not.

A method of compensating the minimum and increasing the accuracy of direction-finder settings has been worked out for long waves. It has been shown that deviations of 90 deg. may occur in the line of propagation of the resultant wave front in the case of very long continuous waves. The facts are fully in accord with the theory of propagation of such waves and the often expressed belief in the existence of media in the various layers of the earth's atmosphere which possess the property of refracting these waves and reflecting them in all directions.

The value of long continuous waves for direction-finder work is, in view of these results, very doubtful. It is, of course, possible that observations taken over a more uniform surface like the sea would not show such marked variations. Observations on long continuous waves would be of value only if the observations cover a considerable period of time and show no very wide fluctuations.

It has been indicated that these results do not cast doubt upon the accuracy of direction-finder observations carried out on short-wave spark stations, since consecutive interference according to a definite plan would not be as likely to occur when a damped wave train is used. The few cases of variations of bearing on spark signals so far observed seem to be accompanied by marked fading effects, as would be expected if they are interference phenomena. Also the minimum was broadened very materially in many cases, but in a few cases a very bad fluctuation in bearing was accompanied by a sharpening rather than a broadening of the minimum. No attempt has been made in any of this work to compensate local deflections so as to get the true bearing, as the sole interest was in time variations and not in local distortions.

It must be concluded that it would be very dangerous to use long continuous waves for direction-finder work at sea until it has been definitely proved that these variations do not occur when transmission is not partly or wholly overland. It is also very likely that even with spark stations it would not be wise to use longer waves than 1500 m. until it has been definitely shown that such waves do not vary in overseas transmission as they occasionally do in overland transmission.

NATURAL GAS NOT ROBBED OF ITS GASOLINE

THE belief which has prevailed in more than 2100 towns and cities in the country where natural gas is used is that it was being robbed of a portion of its heat value by the gas companies through taking the gasoline from the gas has been upset by the result of a series of investigations made by the Bureau of Mines. These showed that the natural gas consumers, which are in excess of 2,000,000, lose practically no heating value through the process. In fact, the Bureau claims that the taking of the gasoline from the natural gas is a benefit to the consumers and to the country as a whole rather than a detriment.

The heat value of 1 gal. of gasoline in natural gas is approximately 1¾ cents while this same quantity of gasoline is worth from 25 cents to 30 cents to the automobile user. By removing the gasoline from the gas 1 gal. will equal 35 cu. ft. of gas but this is not taken from the consumer since the gas is measured at the meter in his residence or place of business and he actually obtains 1000 cu. ft. of gas irrespective of whether the gasoline is removed or not.

When the gasoline was not removed the gas companies experienced difficulty due to the condensation of gasoline and water in the pipe lines, the mixture disintegrating the rubber gaskets in the couplings with a resultant large leakage of gas and the consequent lowering of the pressure. If this gasoline were not taken from the pipes the Bureau states that several hundred million gallons of gasoline of the highest fuel value and adaptability would be practically wasted instead of being added to the country's supply. All of the gasoline obtained in this way has a low boiling point, that is it vaporizes easily, which makes it valuable for starting automobiles, especially in cold weather.

[1]Extracts from scientific paper No. 353 of the Bureau of Standards.

Proposed Constitutional Amendments

AT the Annual Meeting of the Society held in New York City in January four amendments to the Constitution of the Society were presented. These dealt with a change in the minimum age for admission to the Member grade of the Society, a revision in the amount of dues to be paid by Junior members and changes in the composition of the Council and in the method of vacating elective offices.

The proposed amendments, according to section C 56, will be submitted to each voting member of the Society at least sixty days prior to the Summer Meeting, which will be held at Ottawa Beach, Mich., commencing June 21. After discussion and final amendment at that meeting, the amendments will then be submitted by letter ballot on adoption to all members entitled to vote, provided twenty votes are cast in favor of such submission.

The paragraphs of the Constitution which it is proposed shall be amended are given below, the matter which would be omitted if the amendments submitted were adopted, being printed in brackets, and the new passages that would be substituted in italics.

C 8 Member grade shall be composed of persons [twenty-six] *thirty-two* years of age or over, who by previous technical training or experience or by present occupation are qualified to act as designers or constructors of complete automotive apparatus or their important component parts; or to exercise responsible technical supervision of the production of materials germane to the construction of automotive apparatus; or to take responsible charge of automotive engineering work; or to impart technical instruction in the design and construction of automotive apparatus; or who by reason of distinguished service or noteworthy accomplishment would, in the discretion of the Council, appear to be desirable additions to this grade.

Service Member grade shall be composed of persons [twenty-six] *thirty-two* years of age or over, engaged exclusively by the United States Government, the qualifications for this grade being the same as those for Member grade.

Foreign Member grade shall be composed of persons [twenty-six] *thirty-two* years of age or over, resident in countries other than the United States, Canada, Mexico or Cuba. The qualifications for this grade shall be the same as those for Member grade.

A Member who has become eligible for either the Service Member grade or the Foreign Member grade, may upon written request be transferred to such grade and thereafter, beginning with the next fiscal period, shall pay the annual dues for said grade.

C 10 Junior grade shall be composed of persons who at the time of election are under [twenty-six] *thirty-two* years of age and qualified to fill subordinate engineering positions in the automotive or allied industries, or who are regularly enrolled students at or graduates of a technical school. A Junior Member [may upon reaching the age of twenty-six and] shall upon reaching the age of [thirty] *thirty-two* be transferred to Member or Associate grade, in accordance with the decision of the Council as to which grade his qualifications entitle him.

C 21 The annual dues for membership in each grade and for Student Enrollment shall be as follows:

For Member	$15.00
For Associate	15.00
For Junior (*Under twenty-eight years of age*)	5.00
(*Over twenty-eight years of age*)	*15.00*
For Service Member	10.00
For Foreign Member	10.00
For Student Enrollment	3.00
For Departmental Member	None
For one Affiliate Member Representative	15.00
For each additional Affiliate Member Representative	10.00

C 29 The affairs of the Society shall be managed by a board of fifteen directors chosen from among its Members or Honorary Members, which shall be styled "The Council." *The Council shall be chosen from among members who have been in the membership not less than two years; and who have demonstrated by effective work as members of Society or Section Committees, or otherwise, both willingness and fitness to devote time and energy to the accomplishment of Society work.* The Council shall consist of the President, the First Vice-President and five Second Vice-Presidents, [representing motor car, aviation, tractor, marine and stationary internal-combustion engineering respectively,] six Councilors, the Treasurer and the surviving Past-President who last held office. *The five Second Vice-Presidents shall preferably be chosen to represent, respectively, motor car, aviation, tractor, marine and stationary internal-combustion engineering; but when men of suitable standing, experience, and proved desire to serve the Society are not, in the opinion of the Nominating Committee, available from each respective field mentioned, two or more from other fields may be chosen.* Five members of the Council shall constitute a quorum for the transaction of business. The Secretary may take part in the deliberations of the Council, but shall not have a vote therein. The Chairman of the Finance Committee and the Chairman of the Standards Committee may attend the meetings of the Council and take part in the discussion of questions affecting their Committees, but shall not have a vote.

C 34 The Council [may, by a two-thirds vote of the members present, declare any elective office vacant, on the failure of its incumbent for six months, from inability or otherwise, to attend the Council meetings, or to perform the duties of his office, and] *shall declare any elective office vacant in case its incumbent is absent from four successive meetings, or other failure to perform the duties of his office, unless by unanimous vote of the other members of the Council such action is deemed as not being in the best interests of the Society. The Council* shall thereupon appoint a Member or Honorary Member to fill the vacancy until the next Annual Meeting. The said appointment shall not render the appointee ineligible to election to any office.

The Discussion at the Meeting

A report of the discussion of the amendments at the meeting of the Society in January follows.

PRESIDENT CHARLES M. MANLY:—Under the provisions of the Constitution of the Society, amendments can be proposed now to the constitutional amendments which have just been proposed in written form. I would like to ask whether the wording of C-10, under the change pro-

posed, would mean that a man cannot be elected to full membership until he has passed 32 years?

B. B. BACHMAN:—I believe that is the sense of the amendment.

J. E. SCHIPPER:—I would like to ask if that means that present members would revert to Junior standing under such a rule?

MR. BACHMAN:—It is my understanding that it is difficult, if not impossible, to take away from a man, by action of this sort, rights which he already enjoys. I think, therefore, that it could not be possible to make the amendment effective retroactively.

PRESIDENT MANLY:—This whole matter has come up in connection with the work of the Council Grading Committee on membership applications. My understanding is that what it was desired to do is to overcome difficulty experienced at times due to the fact that the Council has before them applications received from men just over 26 years of age, who have professional training that would justify them in expecting to sometime become qualified for full membership, but who, through lack of experience, or other cause, are not really qualified therefor at the time of application. The idea, therefore, was to enable the Council to elect as Juniors men over 26, who are not fully qualified for full membership, but at the same time have sufficient technical training to make it seem undesirable to elect them as Associates.

I had not noticed before that under the amendment proposed no one could become a Member, that is, a full Member, before reaching the age of 32. I think that is undesirable.

As I stated at the 1919 Summer Meeting, I think that one of the greatest reasons for the activity and the broad point of view of the Society is that we keep our membership relatively young, and I hope the day will not come when we impose too great restrictions in the matter of age.

W. G. WALL:—I do not quite get the idea of a Junior member having his dues raised at the age of 28.

HERBERT CHASE:—I am not in a position to speak for the Grading Committee, although I have been a member of it for about two years, but I might explain that at the present time a Junior can come in under the age of 26, and remain a Junior with the lower dues until he is 30. The idea of raising the age limit is to enable men under 32 to come in as Juniors who under present practice would, if over 26, be placed as a rule in the Associate grade because of insufficient experience to qualify for Member grade. If this should be done, the income of the Society might be somewhat curtailed because Associates pay $15 a year. It certainly costs the Society more than $5 a year to carry a Junior, whereas Juniors pay only $5 annual dues. It seems reasonable that a man who has reached the age of 28 can well afford to pay $15 dues. A man who pays the low dues of $5 up to the age of 28 really receives as much special consideration as he is entitled to. In other words, at 28 years of age a man should be earning enough to warrant his paying $15 dues, the same as Members and Associates. These are the reasons for the suggested amendments so far as they concern dues and admission.

It should be borne in mind that the Junior grade is intended for junior engineers, whereas the Associate grade is primarily for men not experienced in engineering work. At present an applicant for membership who is over 26 must be placed in the Associate grade, even though his experience is wholly along engineering lines, if in the opinion of the Council he is not yet a full-fledged engineer, or capable of taking responsible charge of engineering work. Such a man naturally objects to being classed as an Associate, even though he can be and often is later transferred to Member grade, when he has become sufficiently experienced. The proposed change would enable a man to remain in an engineering grade as a Junior until 32 years of age, but simply requires that he pay full dues after he reaches the age of 28. It should not be forgotten that the Junior member receives the same advantages of membership as a full member with the single exception that he, in common with Associates, does not possess the privilege of voting and holding office.

C. F. SCOTT:—May I say a word about the suggested change in regard to term of membership before a man becomes eligible to the Council? For two separate years it has been my privilege to be a member of the Nominating Committee of the Society, and this change appeals to me very strongly as one that will help materially in guiding the deliberations of the future Nominating Committees. Of course we realize that men of the personality, ability and standing sufficient to make them proper members of the Council, and Vice-Presidents and Presidents of the Society, are extremely busy in our industry, but I think this is a fit time to emphasize again the fact that the nomination to office in the Society is not alone an honor. I fancy that if this phase were a little more emphasized the attendance at Council meetings would be greater. I think this provision should be considered with that in view.

PRESIDENT MANLY:—We desire to get the very best results for the Society; that is all we are after. There may be differences of opinion. Do not have any hesitancy in saying what you think. Let us take an active interest in the matter. This is your Society.

FERDINAND JEHLE:—It seems to me that extending the age limit of Junior membership is in accord with the way we have all felt more or less for some time. It is very difficult to recommend a man for membership who has just passed the age of 26. If he had applied three months earlier, he would have been a Junior or an Associate, whereas if he applies after 26, we must make him an Associate or a Member. If a man is only worth Junior grade to us as a Society, I believe that the Society will be worth to him only Junior grade; that is, I think the dues should be the same whether he is 27 or 29, as long as he is of that grade. Maybe the solution will be to raise the Junior dues to $10, no matter what the age is.

I do not think, however, that because a man is not 32 years old, he should not be eligible to election to membership. I think the men who recommend him, and the Council that considers his election, should exercise their judgment in the matter, whether he should be a Junior member.

PRESIDENT MANLY:—I think that the point Mr. Jehle made is a very good one. I do not want to see it become mandatory that a man really otherwise qualified for full membership in the Society, be excluded therefrom simply because he has not passed the age of 32. The Constitutional provision should be elastic enough to permit the Council in its discretion to elect to, and the Grading Committee to recommend for full membership a man of the necessary qualifications.

On the other hand, there is one very important point in this matter, and that is it costs the Society much more than $5 a year to carry a Junior. Now, all of us are the ones who are concerned in the question of how long we are going to carry these men as Juniors, how many of them we are going to carry, and at what age. We can-

not say that we are not concerned because we long ago passed the age of 26, most of us are sorry to say, because we are deeply interested in the welfare of the Society. On the other hand, we do not want to make the dues so high for a Junior member that we will not really get the men in, to train them as they should go in the paths of S. A. E.

H. A. GILLIS:—I have listened with interest to the remarks made here about limiting the age. I do not think that the membership of this Society should be limited to any special age. It is not a question of age; it is a question of qualification. Therefore, I think it should be entirely a matter of the opinion of the Council and the members of the Society who are recommending applicants to the Council, whether a man is qualified for full membership or not. I will cite my own case. I am a Member of the Society, but I believe I am not as well qualified for that grade as some men much younger than myself who have joined the Society only recently and are below the age required for full membership.

I think that the question of age limit is a very important one to the Society's welfare. If this Society is not worth $10 a year to any young man who is going along in his profession, I think that the young man is not worth much to the Society.

PRESIDENT MANLY:—This Society is worth much more than the dues to any member. There is no question about that. In fact, the dues that any member pays for his portion of the work of the Society are not commensurate with the value of the work of the Society. The great point that has always come up in connection with fixing the dues has been not so much a question of what membership is worth, as what it seemed possible for people to well afford to pay, and the desire was to make the Junior membership attractive in a financial way. The more money the Society has the better its work can be carried on, the more we can extend it, and the more valuable we can make it to every member of the Society.

C. H. YOUNG:—I think that another point on this question should be mentioned. I have had much more to do with the membership of another engineering society than with the Society of Automotive Engineers. In the other Society I am a Member; in this I am an Associate. For the past ten years I have had occasion to talk with many young men, and induce them to become members of the other society, and some of the young men, ranging in age from 26 to 32, were eminently qualified to be full members of that society. I am sure that very many young men of that age are qualified for Membership in this Society. Many have graduated from technical schools between the ages of 21 and 23, and have five or six years' good experience; they are keen, their minds are very active and they can contribute some very good ideas to an engineering society. I think that if this matter is adjusted on the age limit solely, there will be much dissatisfaction on the part of the applicants. I think we do not want that to happen.

PRESIDENT MANLY:—I believe that the proper thing is for all of us to think the question over and get ready for amendments to the written proposals that have been made, to be considered at the Summer Meeting. The matter is now before the Society, and will come up again in due course. The main thing I want you to remember is that we are all concerned in this whole matter.

CONTRIBUTED WRITTEN DISCUSSION

L. S. KEILHOLTZ:—The part of the proposed amendments to which I object is the following:

> . . . but when men of suitable standing, experience and proved desire to serve the Society are not, in the opinion of the Nominating Committee, available from each respective field mentioned, two or more from other fields shall be chosen.

I believe that it is the duty of the Society to build up all the automotive divisions so that men of proper qualifications will be available to represent each as Second Vice-president.

Under the proposed constitutional amendment men representing the motor-car industry would probably be nominated and there would be the possibility of a less number of the automotive divisions being represented from year to year officially on its Council. With fifteen members on the Council, at least one should represent each automotive industry.

MR. CHASE:—I was in large part responsible for proposing the amendments, and drafted them in the form submitted. However, they give voice to some pertinent and constructive criticism of the Constitution offered by others.

The objections raised by Mr. Keilholtz to the proposed amendment of C 29 are perhaps natural. Similar beliefs were expressed, I assume, when C 29 was adopted in its present form some years ago to provide for five second vice-presidents. The result has been precisely the condition which the proposed amendments to C 29 and C 34 seek to overcome, namely the Council including in its membership men upon whom honors have been thrust rather than earned by virtue of effective work in and for the Society. In several cases such men have, quite naturally, held the honor so lightly that they have given little or no time to discharging the duties of their office and have attended few, if any, Council meetings. Thus the automotive field they were supposed to represent has not been represented except by other Council members who gave attention to the discharge of their duties.

It has happened in some cases that men of proper caliber were not available in each of the five automotive fields. What we want, as I see it, is a Council composed of men of high standing in the profession, who "have demonstrated * * * both willingness and fitness to devote time and energy to the accomplishment of Society work." With such a Council the Society will be sure to prosper and all of the automotive fields will be better represented, in fact, than if the Council is burdened with members who are representative in name only. I feel sure that, under these circumstances, no field not directly represented will really suffer for lack of representation. Besides, the men who do the committee and other work of the Society are the ones who deserve and should, at least for the most part, be honored by being made officers.

MR. BACHMAN:—With reference to the proposed amendments to the Constitution which were presented at the Annual Meeting by my motion, I would suggest, after having giving the matter additional thought, with reference particularly to the comments made by President Manly, that the amendments as proposed, in their application to C 8, C 10 and C 20, are probably not in a form suited to the best interests of the Society.

In the first place, I feel that in our industry there are a great many men who arrive at a sufficiently high plane in their profession to be entitled to Member grade at a somewhat earlier age than the average for the whole engineering field. At the same time I appreciate, by reason of my past experience, the difficulties encountered, in view of the fact that the Council is prevented

from grading a member as a Junior after he has passed the age of 26.

In view of these facts, I am of the belief that the raising of the requirements for Member grade from 26 to 32 years is too drastic, and does not allow for that desirable flexibility which would be a distinct advantage. It is, therefore, my suggestion that in C 8 the present stipulation of "26 years of age or over" shall be amended to read "28 years of age or over," and that C 10 shall read as proposed to be amended, namely, "Junior Grade shall be composed of persons who at the time of election are under 32 years of age * * *." I believe that the second sentence of C 10 should be amended to read, "A Junior member may upon reaching the age of 28, and shall upon reaching the age of 32, be transferred to Member or Associate Grade * * *."

In C 20, the automatic provision for the increasing of dues of Junior members at the age of 28 years, as suggested in the proposed amendment, meets with my approval.

It may seem that my proposed alterations of the amendments are contradictory, but, after careful thought, I have arrived at the opinion that this is not so.

As I propose, under C 9 the qualification as to age for Members, Service Members and Foreign Members shall be a minimum of 28 years. I believe that this is a fair age limit and will not work a hardship by reason of withholding the grade of Membership from men who have, by their work, indicated their fitness.

With respect to C 10, the advancing of the age limit of Junior members from 26 to 32 permits the Council to place in Junior Grade many applicants who are now perforce assigned to the Associate Grade. At the same time it leaves the way open for a man to make application for transfer at an earlier time.

As to the arguments relative to increasing the Junior membership fee at the age of 28, while a man is still retained in the Junior Grade, or the condition which will arise when a man between 28 and 32 is assigned to Junior Grade, it seems to me that the differential in initiation fee covers this matter sufficiently. Of course, I feel that the provisions of C 22, relative to the payment in difference of initiation fee at the time of transfer should still hold.

COST ANALYSIS AND MOTOR-BUS OPERATION[1]

OUT of the problems of increasing traffic congestion in large cities, has come a new understanding of the conveniences and economies offered by the motor bus. Its acceptance has doomed older forms of transportation, just as the surface cars succeeded the horse-cars and stage-coaches. In Boston, the Eastern Massachusetts Street Railway Co., operating in the Lawrence district, is charging a ten-cent fare, while buses in competition transport passengers on the same route for five cents. Several crosstown surface car lines in New York City shut down because they could not operate profitably on a five-cent fare basis. Buses under municipal control took their place, gave the public quicker and more satisfactory service for the same fare, and did it profitably. The buses of the Fifth Avenue Coach Co. have met with phenomenal success, having already traveled a distance of more than 40,000,000 miles.

In the year, ended Oct. 31, 1919, the Chicago Motor Bus Co. carried 4,106,208 persons on 58,027 round trips. This represents an increase from a daily average of 2229 passengers in 1917, to 78,965 in 1919. This company has recently introduced a new type of bus with enclosed seats on top that will accommodate 60 passengers.

Although the universal use of motor buses for passenger transportation is apparently inevitable, their success depends entirely upon certain elements of organization and operating methods. Bus operators of the present and of the future can well profit by the experiences of the so-called jitney lines that failed through loose organization and cut-throat methods of competition. The majority of these lines were operated by ex-chauffeurs and teamsters who, because of the liberal credit extended by truck dealers, could do business with very little capital. Although their equipment was in most cases inferior, they assumed that it could be operated for as little as the high-grade and more expensive vehicles that are found in the fleets of successful bus-line operators. The unsuccessful operator estimated the cost of gasoline, oil, tires, and driver's wages, and added to this his garage rent and interest on notes. On a basis of what this cost him, plus his profit, he found that he could charge a lower rate than his competitors.

Successful operators know that expenses involving the following items must be taken into consideration:

Fixed Charges

Amortization, or reserve for depreciation
Interest on investment
Insurance: Fire, transportation and theft; public liability and property damage; and collision
Overhead: Administration requirements, taxes and licenses

Maintenance Charges

Garage: Rent, heat, light, power, etc.
Repairs: Material and labor
Overhauling
Painting
Wrecking crew and equipment
Mechanics and inspectors
Battery renewal and charging

Running Costs

Gasoline
Oil
Tires
Wages of drivers, dispatchers, superintendents, etc.
Grease, kerosene and waste

[1]Prepared by D. C. Fenner, manager, public works department, International Motor Co., New York City.

Increasing the Utility of the Tractor

By Arnold P. Yerkes[1] *(Non-Member)* Mid-West Section Paper

IT is now more than fifteen years since the gasoline tractor was first used in quantity for farm work. The tractor is, therefore, almost as old as the automobile and is really older than the motor truck. But in spite of the fact that several million automobiles are in use and a million or more motor trucks, the number of farm tractors in use at the end of 1919 will probably be 100,000 short of the half-million mark.

This comparatively slow introduction of mechanical power for farm operations has been a surprise and a disappointment to many people. Numerous companies have been organized to manufacture tractors under the belief that the business was sure to grow at a tremendous rate, and that there would be room for many companies to manufacture the tractors they had been told that farmers were waiting to buy, and which they must have at once to replace the expensive horse. Company after company has become involved in financial difficulties because the farmers did not take advantage of their opportunity to relieve themselves of this burden. A great many of these early mechanical horses were rather freakish and incapable of meeting the requirements of the farmer; but in addition to the rather long list of machines of poor design and construction, a few, even among the early makes, were sold in large numbers and proved a profitable investment for the farmers.

It is easy to understand why the machines which were deficient failed to sell. It is not quite so clear why the really efficient outfits failed to make greater headway. Some have blamed the poor tractors and their effect upon the farmers for the slow progress made in introducing those of more satisfactory design and quality. Others have thought that no really efficient tractor of just the right size and possessing sufficient all-around usefulness had been produced. They have professed to see a wonderful and immediate market for the tractor that would fully meet the farmers' requirements. Others still believe, or profess to believe, that past and present tractors have been lacking in quality of material and workmanship to such an extent that they failed to meet the farmers' requirements for durability, and that what is needed to give the business proper acceleration and increase sales is the attainment of the highest possible quality, so that the tractors will be capable of working steadily for several seasons on farms, without danger of delays and expense due to breakdowns and repairs.

No doubt the failures of tractors to succeed on some farms has had the effect of making neighboring farmers rather slow to try one, but certainly this cause alone has not been either wholly or in large part responsible for the slow adoption of tractors during the past several years. It may be true also that some farmers are waiting for a tractor capable of a wider variety of work than those now available, although it is difficult to conceive of a wider range of usefulness than is claimed for some machines now on the market, but which do not seem to enjoy any greater rapidity of distribution than other machines of more conservative design and with a shorter list of claimed accomplishments.

As to the need of better quality to increase sales, the tractor would be in a class by itself if highest possible quality were essential to secure its general or extensive adoption. In almost every line of manufactured goods there is a wide range of quality, and this variety exists because the trade demands it. No matter what the article, there is usually a choice of quality ranging from the poorest to the best for which any demand exists. For a few dollars a watch can be purchased which will keep time fairly well and answer all practical purposes. For several hundred dollars one can buy a Swiss hand-made watch which will not vary more than a fraction of a second per month. There is a demand for each kind, but the lower-priced ones sell in the greatest numbers. This should not be overlooked, for it holds true of many other things besides watches, not excepting tractors. Many men who buy watches with high-priced works, and add still further to the cost by getting a handsome case, will, when buying a pocketknife, get a comparatively cheap one, perhaps paying more attention to appearance than to real quality, because they have little use for a knife. But others will spend a greater amount for one having blades of higher-quality steel, because they feel that it pays them to get a knife of good quality. And so with other articles, depending upon the need for their use. The quality depends, to a large extent, upon the amount one is willing to pay. The tractor is no exception. There is some demand for a tractor of highest possible quality, but there is no more reason for having all tractors of this superlative quality than for having all watches Swiss hand-made, or all jackknives hand-forged from crucible steel.

Farm-Tractor Adoption Data

No one can make a thorough study of the existing situation and conclude that any or all of the reasons mentioned are even in a large part responsible for the slowness in adopting the tractor more generally on the farms. It is obvious that there are other strong influences. Most of these are connected with the farm business itself, and by considering the matter in the light of the individual farmer rather than of farmers as a class, these influences become more clear. Considering the subject in its broader aspect and using available statistics, one of the strongest reasons becomes quite obvious. There are on farms in the United States between 300,000,000 and 350,000,000 acres tilled each year. This acreage varies according to market conditions and also according to weather conditions during working seasons. There are about 25,000,000 work horses and mules on farms in this country, or at least one work animal for every 14 acres of tilled land. On a great many general farms where horses are the sole source of power for field work, only one animal is kept for every 30 acres of tilled land and the work is carried on in a very satisfactory manner. It would thus appear that there is at present an abundance of animal power available for farm operations. In spite of the enormous increase in the number of automobiles, motor trucks and tractors, the total number of horses has shown no great decrease, although the latest Government figures show for the first time in several years a decrease in the number of work animals. But the point is that these animals are in the country and, since the

[1]International Harvester Co., Chicago, Ill.

average life of a work horse is about twelve years, at least half can be expected to be still available five or six years hence, and their colts will continue to be raised in large numbers, although in smaller numbers than previously.

The price for work horses has decreased gradually for several years, owing to the high cost of feed and the falling off in the city demand for horses because of the increased use of motor trucks for city hauling. Farmers will not kill off their horses simply to buy tractors; neither will the individual farmer sacrifice his work stock to buy a mechanical powerplant, although he may believe it might prove more efficient and satisfactory than horses. In addition to the very important fact that we have such a plentiful supply of work animals that universal adoption of mechanical power must await their passing, there are three other influential factors necessary to bring about the more general utilization of the tractor.

(1) A lower first cost, or greater financial return for farmers, or both
(2) Perfection of machines and attachments for the tractor and motor truck which will permit their use to better advantage for some of the work for which horses are still used, and also reduce the human labor required
(3) Informing farmers how to reorganize and enlarge their farm business by crop rotation, etc., to utilize the tractor to advantage and also maintain soil fertility

Any suggestion of lower prices for tractors under present conditions seems unreasonable, but either these must come before tractors will be used in really great numbers or farmers as a class must receive greater returns, to make more of them financially able to purchase tractors at present prices. The latter alternative may not appear logical to those who believe farmers as a class are able to buy almost anything. Such a belief is, however, far from being in accord with actual facts. Many people make the mistake of judging farmers as a class. They may have an intimate knowledge of a few individual farmers, their financial circumstances and general surroundings. If they visit friends or relatives on a farm, they are apt to visit those who are more prosperous than the average and have a home and general surroundings conducive to such visits. All farms are not of this nature. A large percentage of American farmers are tenants. Among these tenants many have been hired men or farm boys, who have had little money to begin farming and were gradually working their way up. If they have lived in a community a few years and shown themselves honest and industrious, they can often obtain a farm either on shares or for a small cash rental, even though they have very little stock or equipment. Many retired farmers are willing to advance money. They are accustomed to increasing their powerplants by raising colts, or by purchasing young colts, perhaps working in part payment for them and raising them as cheaply as possible on pasture and roughage otherwise of little value. Many of these tenant farmers are in no financial position to buy tractors even if desirous of so doing. It is true that many of them have sufficient credit to buy a tractor, and the same holds true of many who have passed through the tenant stage and acquired title to a farm, although under a heavy mortgage. A loan to an honest and industrious man with a family is always reasonably safe, and country bankers know this. However, many of these men and their wives hesitate to incur more indebtedness until they have paid off some of the mortgage and perhaps obtained necessities and luxuries which they feel they would rather have than a tractor. In some States nearly half the farmers are renters. A large percentage have comparatively little capital and are making, as a rule, a very small net income. Their available surplus can always be used for buying numerous articles for the comfort and enjoyment of their families, and it is small wonder that so few of them purchase tractors.

In spite of all reports about profiteering on the part of the farmer, the returns on his invested capital and for the amount of work he puts into crop and stock production have been, as a rule, pitifully small. Most farmers today have begun with little or nothing and have gradually acquired land, work stock and other livestock. It is an exception if they have any great sum of money to invest at any time; and, when they do have money to spend, there are many ways in which to spend it. While farmers as a class are getting greater returns than was formerly the case, they must also pay much more for almost everything they need. They are also living on a somewhat higher plane, and naturally do not propose to return to former conditions simply to have money to invest in some particular machine. It is no longer considered wise to keep children out of school following the sixth or seventh grade to help with farm work, but it is more and more common for children to go through high school or college, and this is expensive. The farm lighting plant, a water system for the farmhouse and numerous other improvements practically in the same class with the automobile, must be considered, so far as having the support of the entire family is concerned.

The Farmer's Income

What must the individual farmer spend for all his numerous purchases? Frequently, figures are printed which have been compiled as to the amount of money represented by the total crops produced, and which farmers will have to spend. Most farmers, however, who read such figures must wonder where their share of this sum is. How much money will a farmer be likely to receive from a corn-belt farm of 200 acres, representing a return much above that of the average farm? Corn is the principal cash crop in the corn-belt and the one returning the most profit. Assume that of the 200 acres, 100 acres are in corn. The average yield per acre does not quite reach 40 bu. even in the corn belt, but assuming 40 bu. per acre, the farmer would harvest 4000 bu. Until the war, corn has usually been about 70 cents per bu., but even during the last several years $1.50 per bu. at the farm is a very high estimate. This gives a gross return of $6,000. Suppose the other 100 acres is divided between oats and alfalfa. A fair average for the corn belt is 50 bu. of oats, and 50 acres at this rate would give 2500 bu. At 70 cents per bu., a liberal price, this would be $1,750. Fifty acres of alfalfa with a yield of 3 tons per acre would mean 150 tons, and at $10 per ton at the farm would give a gross return of $1,500. Figuring thus liberally, a 200-acre corn-belt farm could not be expected to produce more than a gross return of $9,250. If this were only a net amount there would be a stronger demand for tractors, even at high prices. Unfortunately, heavy costs such as labor, interest or rent, taxes, seed, overhead charges, etc., must be deducted. A low price for much of the present corn-belt land would be $200 per acre. At 7 per cent the interest on the

land investment of a 200-acre farm would be $2,800. Of course, part of this interest would probably be available to the farmer, but a large percentage of farms have heavy mortgages. It would therefore be not at all too much to deduct $2,000 interest charge from the gross total. The work stock, according to the common estimate, would require 5 acres for each head. At least eight and perhaps ten work horses would be kept on a 200-acre farm today, but the former number, at $125 a year, would cost $1,000. Including board and other expenses another $1,000 will not cover the cost of hired labor. Overhead costs on buildings, fences, machinery, marketing and numerous other items of actually necessary operating expense will in almost every case reduce the net income to considerably below $2,000. This must provide part of the family's living expense, supply them with clothes, furnish the house and provide whatever recreation and luxuries they are to enjoy.

If an absolutely fair calculation is made, it is evident that a farm as large as 200 acres is not apt to return a sufficient profit to allow a farmer any great amount of money to invest in new machinery. The income from farms is, as a general rule, in direct proportion to their size for any given type. On corn-belt farms of 80 to 160 acres, the net returns are very low compared with those from most other kinds of business having anything like an equal investment of capital. Numerous investigations have shown without exception that the net income from farming is very small. In spite of all that may be said and believed regarding their enormous profits, farmers appear to be anything but satisfied with conditions as they have existed in the past and are found at present. Farmers show almost as much unrest and dissatisfaction today as labor unions show. On every hand they are endeavoring with more or less success to better their conditions and obtain a more adequate return for their labor. The Non-Partisan League movement in the Northwest is one evidence of this. The forming of numerous cooperative associations is further evidence, and to show the frame of mind of many farmers, attention may be called to the resolution recently passed by the Indiana Division of the Farmers' Educational and Cooperative Union, which called for a reduction of 25 per cent in the acreage planted to crops in 1920. The effect of carrying out such a resolution would be far-reaching, as is obvious. Nevertheless, it is quite likely that it will be carried out to a great extent. At any rate, reports already received as to the acreage of fall-sown grains in Illinois show a very heavy decrease, amounting to 50 per cent in some counties.

These conditions might at first glance seem to have little relation to the sale of tractors, but they do have a very strong influence. The farmer is in a peculiar position. He can always procure a fairly good living from his farm. If he and his family are willing to stint themselves somewhat in regard to articles which must be purchased, they can continue to exist even though the money returns from crops are extremely low. This fact has been largely responsible for so many farmers remaining in the business when they were not receiving an adequate return for their labor and invested capital. It enables them to reduce their tilled acreage and so cut down their expense for hired labor and operating cost, resulting in a public shortage of food supplies, which may still return them fully as much as a larger crop at lower prices. While thousands of farmers are in this frame of mind, it is useless to expect them to buy tractors. The real solution of their problem undoubtedly lies in increasing rather than decreasing their acreage, and in bringing about greater returns for their labor through the more efficient utilization of their labor by large labor-saving machines. Unfortunately, this is not being pointed out to them to any great extent.

It is impossible to calculate with any degree of accuracy the probable market for tractors today, without taking into consideration the economic problems with which farmers are confronted. The changed conditions brought about by the war have affected the farmer almost as much as the business man. The labor situation is perhaps even worse from the farmer's standpoint than from that of the industrial employer.

Human Versus Mechanical Labor

In two principal ways, farmers attempt to free themselves from the hired-help problem. One is to cut down the acreage being farmed and either engage in dairying to some extent or undertake the growing of crops which will provide employment for a large number of days each year, can be handled with little or no extra help and, because of the large amount of labor involved, return a greater amount of money per acre than crops usually grown by machinery. The other solution is to increase the size of the farm to permit utilization of the largest and most efficient labor-saving machinery, to operate on a sufficient scale to permit paying wages on a competitive basis with city industries and to provide enough work for both men and equipment to justify the necessary investment and overhead charges.

A number of companies and corporations have been formed within the past few years to carry on farming on a large and efficient scale, and this movement has doubtless just begun. Most of those engineered by experienced farmers seem to have proved profitable. Some have involved the growing of perishable truck crops and small fruits; others, general farming only. One of the largest and most recently formed is reported to be a $20,000,000 corporation to handle fruits only. This organization, like most of the others, expects to reduce the overhead charges through buying supplies and equipment in large lots, proper advertising of the product, ability to handle the entire marketing problem in a much better manner, using tractors and other large machines in all field work. Their financial resources will permit them to buy an adequate supply of the most modern machinery, and their large acreages will fully justify it. Great benefits have been predicted from these large farming schemes, and there are certainly enough possibilities in them to cause many more to be undertaken. One of them is of more than usual interest, because it was backed largely by representative capitalists and inaugurated as a war measure. It was planned on a magnificent scale, and was located on several thousand acres of Indian land. This section was recently stricken by a drought, and the wheat crop was a total failure. This experience should give business men a better conception of the risks involved in farming. It also shows that even though a farmer may make money some years, such profits must make up for the bad seasons which occur too frequently, even in desirable farming regions.

It has often been stated that there is no such thing as an average farm and it is just as true that there is no such thing as an average farmer. There are always great variations in the problems presented by any two farms. To classify them, the best that can be done is to place in a group those that are least dissimilar. In

this great dissimilarity of farms and farmers lies another reason for the slow rate at which tractors have been bought. It does not follow that because one man on a 240-acre farm in the corn belt finds a tractor profitable, his neighbor with the same size farm will find a tractor equally profitable. The crop rotations on the two farms may be quite different. One farmer may like horses and raise colts for sale, while the other does not; one may be a good hand with machinery or may have a son or hired man who can operate a tractor satisfactorily, while the other may not; one may depend upon hired help, while the other may have boys of his own to assist him; one may have passed middle age and, like most elderly people, be rather averse to making any radical changes in his methods or equipment, while the other may be young, energetic and perfectly willing to try something new; one may have money laid aside either as the fruit of his own labor or through inheritance, while the other may be financially handicapped; and one may have excellent credit with his bankers and local business men, while the credit of the other may be poor. Thousands of other variations could be listed, each one of which actually exists in some instance. The size and type of farm are far from being the only factors which determine whether a tractor will be practical and whether it is likely to be used.

Equipment and Method Changes

Attempting to put a tractor on every farm above a certain acreage would be like trying to sell a motor truck or delivery car to every corner grocer in our cities. In Chicago, there are hundreds of small grocers who each maintain a horse and wagon for hauling goods from the wholesale house and delivering to customers. This does not mean that automobile delivery is not quicker, cheaper and more desirable in almost every way, but that the horse and wagon have in many cases been owned for a number of years, are still serviceable and meeting the requirements. Even if the storekeeper desired to sell his present outfit and purchase an automobile, he would find a very poor market for either the horse or wagon; hence, the new equipment would mean a considerable investment increase and an actual loss through the sacrificing of serviceable equipment. So long as he sees no probability of an increase in his business that the horse and wagon would be incapable of caring for, he is not likely to make a change. If his profits were more than necessary for the living expenses of himself and family he would probably spend the surplus for a passenger car rather than a new delivery vehicle. This is simply human nature and explains the enormous sale of automobiles to farmers, who do not buy tractors so freely.

The farmer is not alone in his inclination to continue using equipment which has proved adequate. It is nearly as difficult to sell new and improved machines to any other business man or manufacturer as to the farmer. It is only in newly built factories that the most improved machinery and equipment are found throughout. In older factories one is sure to find machines and equipment that are out-of-date and less efficient than other machines on the market. Hundreds of instances might be cited where large manufacturers are using methods and equipment which are out-of-date and much less efficient than later methods; but, so long as the old equipment continues fairly satisfactory, it is used because the loss through sacrificing it to buy the newest and most improved equipment will often more than offset the slightly greater labor cost in operating the out-of-date equipment. Furthermore, manufacturers often take the attitude that the newer and more improved machinery will probably become cheaper, or that further improvements may be made that will justify waiting. Farmers are fully as well justified in taking this course. Most farmers, although they may have made a fairly large investment, are receiving such small returns that they cannot afford to risk a large amount in an experiment. They like to be as nearly certain as possible that any new machine they buy will return a good profit.

It is but natural that farmers watch very closely how their neighbors' tractors are working out. The tractor manufacturers should answer very frankly, to themselves at least, what has been the result of such observations. It is true that a high percantage of tractors bought within the last several years have proved satisfactory to their users. Most owners will say that the machines have been profitable, but in order to get down to actual facts it is desirable that everyone realize just what these machines are actually doing for the men who own them. The farmer who is considering the purchase of a tractor should not be expected to take a particularly optimistic view and see things in a more attractive light than the facts actually warrant. He is rather critical of the performance of the machines, and the facts and figures as to what they have actually been doing certainly do not constitute a great incentive to hasten the farmer's purchase.

In advertising tractors and in attempting to emphasize their advantages over horses, the statement has been made repeatedly that the farm horse works on an average only about 100 days per year. This was intended to show that he was inefficient as a source of farm power and used only for field work, while the tractor could be used for belt work also. Figures obtained from tractor owners as to the number of days they use their machines for different kinds of work and as to the total number of days the tractor could be used each year, disclosed the fact that the tractor was generally used not to exceed 50 days per yr. and that on many types of farm it was used about half of this time at belt work. This was almost incredible to many people and its accuracy was questioned. Further investigation, however, showed that it was too high rather than too low an average.

Efforts to Increase Tractor Utilization

Some manufacturers, realizing that the tractor was being used so few days per year, that its work was largely limited to plowing and belt work and that horses were doing harrowing, disking, seeding and other operations following plowing, attempted to make the tractor more generally useful. They encouraged its use for practically all kinds of field operations, bringing out special harrows, disks, drills, harvesters and other machines to make the tractor more suitable for these operations. It was hoped that the perfecting of such machines for use with the tractor would result in its being used a much greater number of days annually.

Not many figures obtained within the past year are available to check up this expectation. Such as are available, however, do not indicate that the desired result has been accomplished. L. A. Reynoldson of the office of farm management of the Department of Agriculture, visited 141 corn-belt farms where tractors were used in the summer of 1919, and obtained from the

operators the number of days the tractor had been used in the different kinds of farm operation and also the time that horses had been used. These data differed slightly from most that had been obtained previously. Instead of taking the total number of days on which the tractor had been used for belt or field work, the owners gave as nearly as possible the number of full days the tractor had been used. If a farmer used his tractor 2 hr. of 1 day each week to grind feed, instead of reporting the tractor used for 52 days for grinding feed, the figure would be 10.4 days. The investigation showed that tractors on the 141 farms visited were used only 29 days each year on the average. Horses kept by these tractor owners decreased, on an average, two and one-half per farm, while the average size of farm had increased 24 acres. The horses remaining on these farms were used an average of 78 days per year. For the average farm, 565 days of horse labor was distributed among the various operations in order of their importance, rated on the number of days' labor involved, as follows:

	Days
Harvesting corn	100
Corn cultivating	84
Disking, harrowing, etc.	71
Road hauling	63
Hauling manure	48
Threshing	44
Plowing	33
Haying	29
Drilling	25
Cutting grain	24
Corn planting	16
Miscellaneous	28

The neighbors of these tractor owners would not receive much encouragement from such tractor performance unless their owners were getting much better yields than farmers using horses, or enjoying a greater profit by having their crops planted and harvested in season. These theoretical advantages, however, are not realized every season and the observer might not give them full benefit of their advantages along these lines.

Why do the farmers not make better use of their tractors? For an outfit costing $1,500 and used only 30 days each year, the interest charge alone would be about $3 per day, and depreciation, based upon a life of 10 yr., would be $5 per day. One must admit that a farmer has much better reason to put off purchasing a machine which he can use only 30 days each year than a manufacturer has for postponing the purchase of an improved machine that he can probably use every day. The average size of the farms on which the 141 tractors mentioned were used was 346 acres, which is considerably higher than the average for the country or even for the corn belt. As would be expected, the number of days the tractors were used annually increased almost directly with the size of the farm. On farms of 220 acres and less, the tractors were used only about 20 days on an average, while on 380 to 700-acre farms they were used about 36 days. This merely reaffirms the fact that to utilize the tractor to advantage there must be enough acreage to keep it busy for a reasonable period each year. The number of days horses were used for various operations shows the need of developing more machines and attachments to make the tractor or truck suitable for the different kinds of work. For some, the motor cultivator will undoubtedly be used; for others, the truck will be more satisfactory than horses; for road hauling, hauling manure and probably some of the other work such as haying, corn harvesting, etc., the truck will have its place.

Granting that the sale of tractors has not been all that could be desired and that this condition can be improved upon, the principal question is how to overcome the obstacles which have interfered with the development of the business, so that the tractor will be generally adopted for farm work. First, the initial cost of a tractor must be such as to make it practicable for a business of the magnitude of a large percentage of farms. Second, it is obvious that what is commonly termed intensive cultivation, meaning the growing of crops by hand methods on small areas, does not tend to increase the sale of large machines of any kind, tractors, included. But extensive farming, the raising of crops on a large scale with a minimum of human labor through the use of large labor-saving machines, does tend to encourage the use of all kinds of improved equipment, including tractors. Less consideration should be given to 10-acre farms and more to 1000-acre farms; the latter can use tractors to advantage; the former cannot. The problem will solve itself if things are allowed to take their own course, or the solution can be hastened by proper action. At present, farmers receive advice on practically every subject connected with farming except on the use of labor-saving machines. All kinds of experiments and investigations are being carried on in the breeding of live stock and better crops; likewise, experiments in the building up and maintenance of soil fertility are being carried on in great number. Such detailed information can be obtained by any farmer who wishes it, but regarding information as to the best crop rotation and acreage to make use of a tractor efficiently, little is available.

It is unreasonable to expect each individual farmer to be capable of working out an organization and crop rotation for his farm which should make it possible and practicable for him to use a tractor. He is not much more likely to do this than he is to breed a better variety of wheat by hybridizing. Some individuals will solve their own problems of this kind. The large percentage of tractor owners who enlarge their farms and increase their returns by a better farm organization on an extensive scale are ample proof of this. What is needed is to ascertain just exactly how these successful users have reorganized, and to pass this information on to other farmers. Organizations are now teaching farmers how to treat their hogs for cholera, how to fumigate seed and inoculate soil, and are giving other information which adds to general prosperity. The farmer should be told how to change over from a small and inefficient plant where human labor is being wasted, to a larger and efficient food-production organization, on which he can practise the same principles of quantity production as are practised by large manufacturers today. Farming needs to be put on a quantity production basis fully as much as does any other industry for the good of the individual farmer and of the country as a whole.

Landing Run and Get-Away for Standard Airplanes

By ALEXANDER KLEMIN[1] (*Member*)

AERONAUTIC MEETING PAPER *Illustrated with* DRAWINGS AND CHARTS

ASSOCIATION with the air mail service leads me to the conclusion that the length of the landing run constitutes one of the greatest practical airplane problems, particularly when using the fields now available. A fast, heavily-loaded machine has excellencies of its own but is not likely to be capable of a short run; a powerfully-acting tail-skid, while giving full braking effect, is likely to damage a field and at the same time impose undue stresses upon the fuselage. In the case of forced landings, it is particularly important to have as short a landing run as possible. The mechanics of the airplane in the air have been exhaustively studied, but no mathematical considerations or conclusions are available concerning landing runs.

Considering the case of a three-point landing, with the engine shut off, in which the pilot flattens out after a dive, places his machine in a stalling attitude and gradually loses speed, until the wheels and the skid touch the ground simultaneously. The machine then slows down under the combined action of the aerodynamic and tractive resistances. During taxiing with the machine retaining the same attitude, the aerodynamic resistance is proportional to the square of the speed. The tractive resistance is proportional to the reaction of the ground, this being proportional to the weight of the plane minus the remaining lift due to the wings.

The equation of motion then becomes

$$\frac{W}{g}\int\frac{d^2x}{dt^2} = -c_1v^2 - c_3\,(W - c_2v^2), \text{ where}$$

x=the distance, measured from the landing point
W=the weight of the airplane in pounds
g=acceleration due to gravity
d=differential
t=the time in seconds
v=the velocity at any point
c_1=a constant defining the aerodynamic resistance
c_2=a constant defining the aerodynamic lift
c_3=the tractive coefficient.

$$\text{Let } \frac{g(c_1 - c_2c_3)}{W} = K_1, \text{ and } gc_3 = K_2$$

The equation can then be written more simply as

$$\frac{d^2x}{dt^2} = -K_1v^2 - K_2 \text{ or}$$

$$v\left(\frac{dv}{dx}\right) = -K_1v^2 - K_2, \text{ or}$$

$$v\left(\frac{dv}{dx}\right) = -K_1\left(v^2 + \frac{K_2}{K_1}\right), \text{ therefore}$$

$$2K_1x = -\int\frac{2vdv}{v^2 + \frac{K_2}{K_1}} = -log\left(v^2 + \frac{K_2}{K_1}\right) + A.$$

When $x = 0$, $v = V_0$, where V_0 is the initial speed and

$$A = log\left(V_0^2 + \frac{K_2}{K_1}\right).$$

The length of the landing run x_l is therefore given by the expression

$$x_l = \frac{1}{2K_1}\left\{log_e\left(\frac{V_0^2 + \frac{K_2}{K_1}}{\frac{K_2}{K_1}}\right)\right\}$$

$$= \frac{1}{2K_1}\left\{log_e\left(\frac{K_1}{K_2}V_0^2 + 1\right)\right\}.$$

Replacing the original constants by substitution

$$x_l = \frac{W}{2g(c_1 - c_2c_3)}\left\{log_e\left[\left(\frac{c_1 - c_2c_3}{Wc_3}\right)V_0^2 + 1\right]\right\}$$

Since $c_2V_0^2 = W$, this expression can be simplified to

$$x_l = \frac{c_2V_0^2}{2g(c_1 - c_2c_3)}\left\{log_e\frac{c_1V_0^2}{c_3W}\right\}$$

$$= \frac{\frac{c_2}{c_1}V_0^2}{2g\left(1 - \frac{c_2c_3}{c_1}\right)}\left\{log_e\frac{c_1c_2V_0^2}{c_2c_3W}\right\}$$

Writing $\frac{c_2}{c_1} = \frac{L}{D} = \frac{\text{lift}}{\text{drift}}$ at taxiing attitude, the expression becomes

$$x_l = \frac{(L/D)V_0^2}{2g[1 - (L/D)c_3]}log_e\left\{\frac{1}{(L/D)c_3}\right\}$$

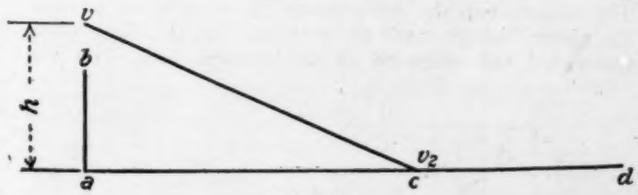


FIG. 1

This expression clearly gives an idea as to what extent well-known factors enter in determining the length of run, and shows that this length will be longest if L/D and V_0^2 are large while c_3 is small. It also provides us with a formula from which, knowing the tractive resistance and the aerodynamic properties of the machine, the length of landing run can be determined at once. At present there appears to be little experimental data available for the verification of the above formula under conditions of service.

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On May 23, 1919, a comparative test was conducted by the Air Mail Service on the Curtiss R-4-L and the Curtiss HA mail machines at Roosevelt Field, which has well-sodded ground and was in good, dry condition at the time of the test.

Data on the two machines are given in the accompanying table.

Machine	HA	R-4-L
Test load, lb.	4,018	4,200
Engine	Curtiss K-12	Liberty-12
Rated power, hp.	400	400
Wing area, sq. ft.	490.0	504.9
Wing section	Sloane	R.A.F. 6
Angle of incidence of wings to propeller thrust, deg.	0	2.5
Landing angle, deg.	16	14
Ky at landing angle	0.00246	0.00305
Landing speed, m.p.h.	56.5	52.0
Wing resistance, lb.	1,140	452
Parasite resistance, lb.	125	136
Total resistance, lb.	1,265	588
L/D at landing angle	3.15	7.15
Tractive resistance, lb.	440	500
Traction coefficient	0.104	0.119

Applying the formula previously given for the length of landing run gave values of 560 and 750 ft. respectively for the two machines. The actual test results were 539 and 711 ft. respectively. These results, even though based only upon two tests, are encouraging. It would seem that, with reasonable accuracy in the assumptions, concordance can be expected between the actual length of the run and the computed results such as are indicated.

It is interesting to review these results. A hasty consideration of the two machines might have led to the conclusion that the R-4-L machine, with its lower landing speed, higher tractive resistance and uglier design, would have had a much shorter landing run than that of the HA machine, whereas the latter actually had a shorter run. This can be explained only by the fact that the HA machine can be set down at a larger angle, and the wings thus furnish an enormous resistance. It is the importance of a large angle of incidence for the wings which is emphasized.

It is interesting in this respect to quote from some experiments made by the British Royal Aircraft Factory. Tests were conducted on the B.E. 2c and R.E. 7, two well-known British machines, for the purpose of finding the distance run after landing and the total space required after clearing a 6-ft. hedge.

The measurements were made by stretching a tape 6 ft. above the ground, as at *b* in Fig. 1. The pilot maneuvered the machine so as to clear this, and its

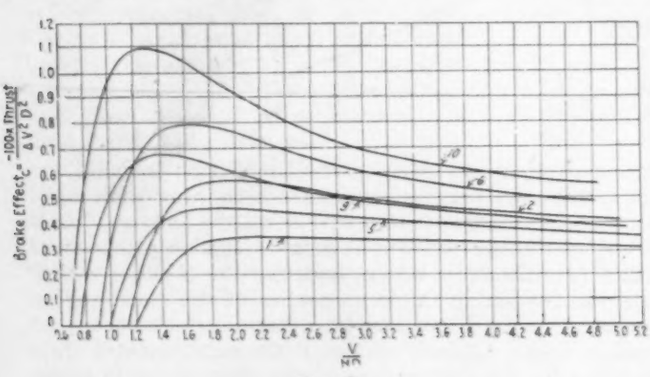
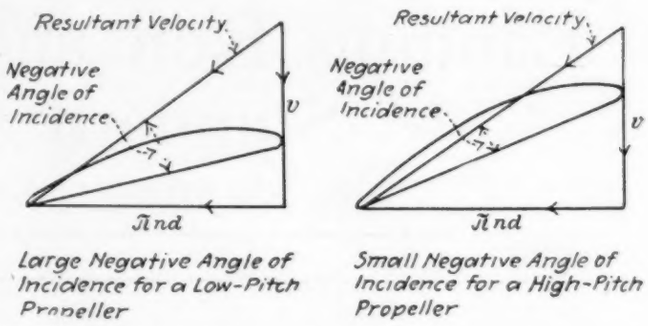


FIG. 2



Large Negative Angle of Incidence for a Low-Pitch Propeller

Small Negative Angle of Incidence for a High-Pitch Propeller

FIG. 3

height above the tape, *h*, was observed from the ground. An observer in the machine read the air speed, V_1, and then read V_2 when the wheels touched the ground. The distances *ac* and *cd* were then measured, *d* being the point directly below the propeller boss where the machine stopped. The calmest days were chosen for the experiments. The landings were made against the wind and the wind velocity was recorded.

Experiments on the B.E. 2c were repeated with an arrangement such that with the tail on the ground the angle of incidence was increased. The alteration made was to shorten the top longitudinals of the rear part of the body and thus raise the skid. The increase in the angle of incidence was 3 deg. and the total space required for landing was 20 per cent less than with the standard arrangement, the distance run after touching the ground being reduced by about 35 per cent.

The following were the average values for a good landing over a 6-ft. hedge, with no wind:

	ac	*cd*	*ad*
B.E 2c standard machine.....	200	550	750
B.E. 2c machine with tail raised....	200	400	600

No very exact data are available on the B.E. 2c machine. The B.E. 2 machine, from which it was developed, weighs 1650 lb., has a landing speed of 40 m.p. h. and a parasite resistance of 87.6 lb. at 60 m. p. h. The machine is only moderately neat in design. These figures are merely interesting as giving a general idea of the length of landing run for a smaller and slower machine.

The Propeller on a Landing Run

Some difference of opinion exists as to the proper method of handling the engine to insure a short run. If the speed of the engine is maintained above a given number of revolutions per minute, the propeller will continue to develop a positive thrust. If the engine can be throttled to a lower speed, the propeller may develop a negative thrust. If the engine is completely dead, and at rest, the propeller will offer resistance because of its resistance-producing area. When the engine is dead but the propeller is still revolving, the braking effect of the propeller acting as a windmill or air turbine may be important, but only when the forward speed is very great, as on a dive.

Let us consider whether any appreciable braking effect can be secured by running the engine on the ground at a very low speed, instead of completely stopping it. As an example take propeller No. 5 of Dr. W. F. Durand's report No. 14 for the National Advisory Committee for Aeronautics. Assume it to have a diameter of 9½ ft. and that it is used with a Liberty engine having a max-

imum speed of 1700 r.p.m. in level flight near the ground. The V/nD ratio at a speed of 110 m.p.h., which closely approximates the case of the Curtiss R-4-L machine, is $\frac{110\times1.46}{27.4\times9.5}=0.62$. In this ratio V is the airplane speed in miles per hour, n the engine speed in revolutions per minute and D the propeller diameter in feet. The thrust

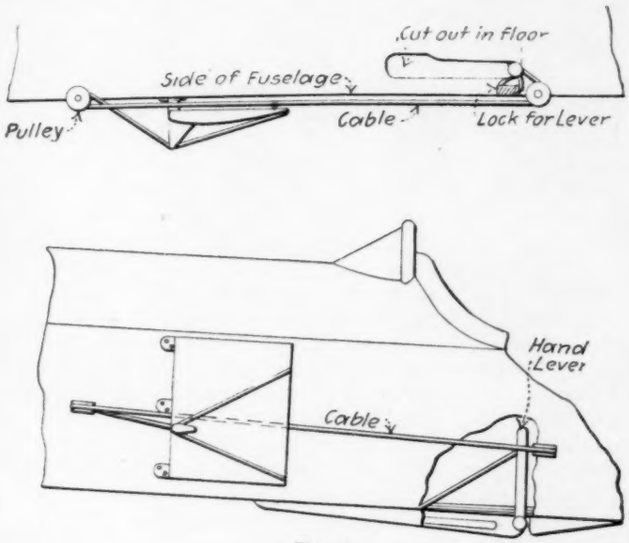


Fig. 4

coefficient from Plate VI in Dr. Durand's report is 0.55 and the thrust is given by the formula

$$T=\frac{T_c D^2V^2\triangle}{100},\text{ where}$$

$\triangle = 0.0761$, the density of the air

Applying the formula

$$T=\frac{0.55\times(9.5)^2\times(160)^2\times0.0761}{100}=965\text{ lb.}$$

The torque coefficient is 0.78 so that the torque is

$$Q=\frac{Q_c D^3V^2\triangle}{1000}$$
$$=\frac{0.78\times(9.5)^3\times(160)^2\times0.0761}{1000}$$
$$=1270\text{ lb.-ft.}$$

The power under the above conditions is 410 hp., which the Liberty engine can just develop. The efficiency is 69 per cent, showing that the propeller would be fairly suitable for the R-4-L Curtiss machine.

In the National Advisory Committee's Report No. 30, results are given for the same propeller at negative thrust for very high values of V/nD. Suppose we consider 52 m.p.h. the landing speed of the R-4-L machine. The negative thrust as given by the formula is

$$\frac{(\text{Brake-effect coefficient})\ \triangle\ D^2V^2}{100}$$

and its maximum value occurs at a value of V/nD of approximately 1.8 when the brake-effect coefficient has a maximum value of 0.46. The engine speed for this value of V/nD must be 270 r.p.m. and the thrust will be

$$\frac{0.46\times(9.5)^2\times(76)^2\times0.0761}{100}=182\text{ lb.}$$

No power curves are given for the test and the objection might be made that to produce this negative thrust, the Liberty engine would have to develop more power than it can deliver at 270 r.p.m. The negative thrust as thus developed is only equivalent to 24 hp., however, and if the V/nD ratio were decreased to 1.2 by increasing the engine speed to 405 r.p.m., the negative thrust would still be 127 lb.

The Durand propeller No. 5 was selected quite at random, and yet the maximum possible thrust is found to be 182 lb. for the landing speed of the R-4-L machine. Since this is about 40 lb. more than the skid drag of the same machine, it is by no means negligible but this propeller is not a very good illustration of what it is possible to do with a propeller in the region of negative thrust. In the curves of Fig. 2, taken from Plate XXX of Report No. 30, it is seen that the brake-effect coefficient at its maximum is not so very much greater than the approximately asymptotic value of the coefficient, at very high values of V/nD when the number of revolutions per minute become very small. With such a propeller, the maximum brake-effect coefficient would therefore not be so very much greater than if the propeller were not revolving, and thus opposing forward motion simply by virtue of its resistance area.

But the brake-effect coefficient of propeller No. 10, as indicated in the same series of curves, is more than twice as great as that of propeller No. 5, and at an airplane speed of 52 m.p.h., a V/nD ratio of 1.2 and engine speed of 410 r.p.m., would, with the same propeller diameter of 9½ ft., give a negative thrust of 400 lb., which would check the landing run very rapidly. Moreover, propeller No. 10 has a maximum brake-effect coefficient much greater than the values shown on the curves for very large values of V/nD and approaching the condition of a non-revolving propeller.

The investigation of Report No. 30 indicates that for a given size of propeller, wide blades have a larger brake effect than narrow blades, and that the brake effect of the higher-pitch propeller is less than that of the lower-pitch propeller. The latter result is quite reasonable as

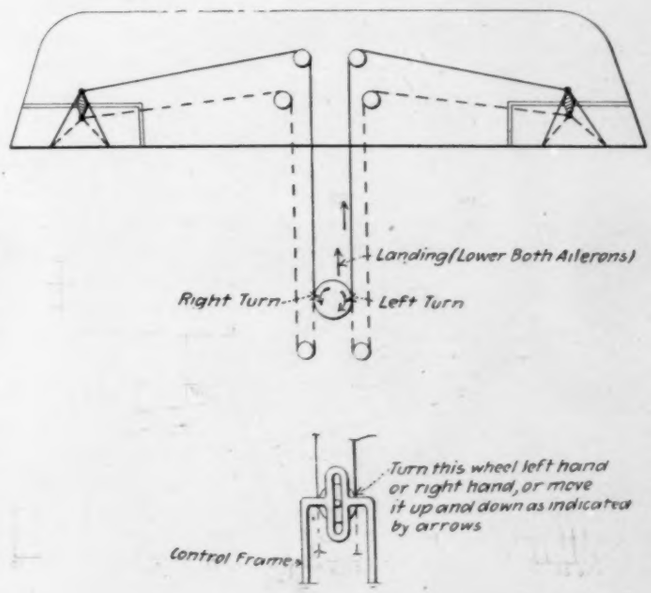

Landing (Lower Both Ailerons)
Right Turn
Left Turn
Turn this wheel left hand or right hand, or move it up and down as indicated by arrows
Control Frame

Fig. 5

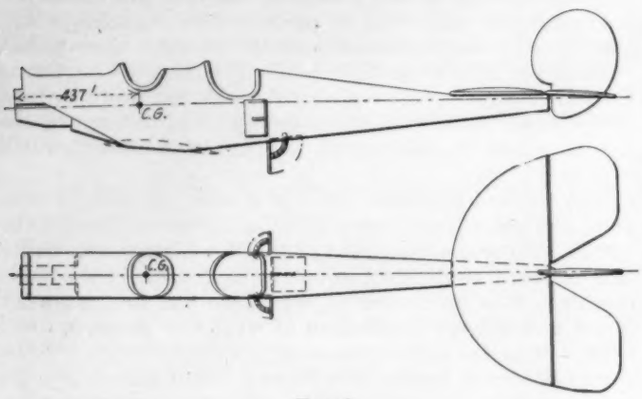


FIG. 6

can be seen from the diagrammatic representation in Fig. 3, since with a low-pitch propeller the tendency will be for the air to strike the propeller blade element at a larger negative angle to the chord.

An objection might be made that as the landing run proceeded and V decreased, the V/nD ratio would decrease so that the pilot would run the propeller into a region of low brake-effect coefficient, or even of positive thrust, and it is quite possible that pilots may at first find considerable difficulty in getting the best braking effect. But with a broad-blade, low-pitch propeller, it seems quite conclusive that pilots would find an advantage in experimenting on their landing run until they found the best possible combination. The shortening of the landing run resulting therefrom might make all the difference between a poor and a good commercial machine.

DEVICES FOR SHORTENING LANDING RUNS

The most obvious device for shortening a landing run is the use of an airbrake consisting of flat plates hinged at the sides of the fuselage. To avoid the effort which is required to operate such brakes, it is advisable to have the plates arranged so that the relative wind will force the side plates to open while the opening of the under flap is retarded by the wind. A fairly simple arrangement for the control of such an airbrake is shown in Fig. 4. This type of brake has been used on British machines, but objections can be raised to its employment on the grounds of complication and also that the resistance of the brakes diminishes rapidly as the speed decreases.

In a British test, the model body RE-1, shown in Fig. 5, had a length of 25½ in. or one-twelfth of the full size, and a brake area of approximately 0.0358 sq. ft. In a 40-ft. per sec. wind, the increase in drift due to a 90-deg. opening of the brakes was 0.0804 lb., giving a brake-effect coefficient of 0.003 per sq. ft. per m.p.h. This indicates that airbrakes will offer practically the same resistance as flat plates freely exposed.

The full-size area of the brakes for the RE-1 is 5.15 sq. ft. Imagine brakes of 10-sq. ft. area applied to the Curtiss R-4-L machine, whose landing run has been previously discussed and which is a larger machine than the RE-1. The resistance at 52 m.p.h. will be 81.5 lb. and the L/D ratio becomes 6.3. The calculated run now becomes 680 ft. instead of the 750 ft. previously computed. It is quite clear from this that the effect of airbrakes is small, and hardly worth inclusion. On a very small machine it is possible that brakes of a large size relative to the wing area might be included with more satisfactory results.

While airbrakes may be set aside as entirely unpromising, the use of wing flaps extending over almost the entire trailing edge is worthy of the most serious consideration. This device has been used successfully in a Sopwith 110 Clerget single-seat seaplane and in a seaplane built by the Fairey Aviation Co. A diagrammatic scheme for a proposed employment of wing flaps without disturbing the functions of the ailerons is shown in Fig. 6.

In some British experiments carried out on an R.A.F.9 wing section with the hinged rear portion occurring at 0.385 of the chord, the maximum lift obtainable was increased in the ratio of 1.35 to 1, the flap being set at 60 deg. to the wing. This maximum lift occurs when the angle of incidence of the wing proper is in the neighborhood of 4 to 6 deg. Such an increase in the maximum lift would decrease the landing speed in the ratio of 1 to 0.865. If the flap were used intelligently by the pilot, it could be used effectively as a brake, after the machine had settled at a speed and attitude corresponding to the maximum lift, by being set at a maximum pitch of 90 deg. to the wing, with the wing itself at an attitude corresponding to a three-point landing. Even when the flap was only set at a 45-deg. positive angle to the wing, the drift of the R.A.F.9 at 14 deg. was increased in the ratio of 5.45 to 1.

If the mechanism were applied to the Curtiss R-4-L machine and used as already explained, with flap set at a positive 60-deg. angle for landing and a positive 90-deg. angle for braking, the landing speed would become 45 m.p.h. and the landing run would be reduced to about 200 ft., as compared with the 750 ft. previously computed. A definite conclusion would be that wing flaps extending along the rear edge would be of very appreciable help.

It is very often assumed that a variable-pitch propeller will decrease the landing speed by imposing a large negative thrust on the airplane in the dive. A short consideration of the problem will indicate that this conception is erroneous. Consider Fig. 7, where t

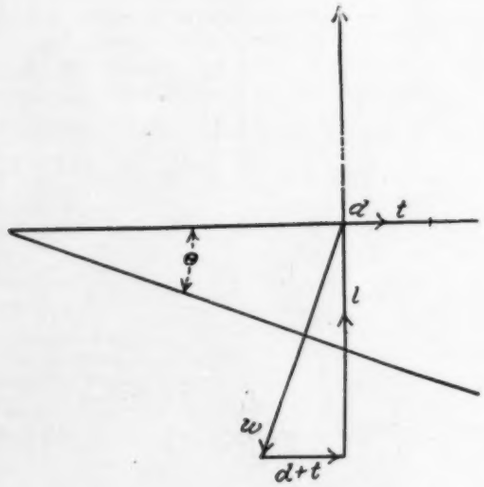


FIG. 7

represents the negative propeller thrust. The equations of equilibrium are

$$l = w \cos \Theta = K_y A V^2$$

$$w \sin \Theta = (K_x + K_p) A V^2 + t$$

$$\tan \Theta = \frac{K_x + K_p}{K_y} + \frac{t}{K_y A V^2}, \text{ where}$$

l = lift

w = weight

Θ = angle of flight

K_y = lift coefficient

K_x = wing-drag coefficient

K_p = parasite resistance coefficient

V = velocity

A = lifting area

t = thrust

For small angles of glide, where cos Θ is close to unity, the effect of a negative propeller thrust will be simply to increase Θ for any speed of glide of the machine. It is only on a very steep, almost vertical, dive that the negative thrust will act usefully by keeping down the terminal velocity. On recovery from the dive, the negative propeller thrust will have no effect upon the landing speed, which will always be defined by the maximum K_y of the plane. The variable-pitch propeller will, however, have a very powerful effect indeed on the landing run and will be probably the most efficacious method of braking possible.

In Fig. 8, the forward skid arrangements for the English Avro and the Ace machines are shown. Such arrangements are equivalent to the placing of an extra tail-skid and an extra tractive effect, without the inconveniences entailed in carrying the center of gravity far behind the wheels, which means difficulties in get-away and a damaging effect on the field due to an extremely heavy tail-skid load. If, in the Curtiss R-4-L machine, the skid tractive effect of 140 lb. were increased to 280 lb. by the use of a forward skid, the computed run would be shortened to 615 ft. instead of 750 ft., which is an appreciable difference.

Brakes on wheels have been avoided hitherto because of the tendency induced of nosing the machine over, but with a small forward wheel or skid they might become a very useful device.

Length of Get-Away

It is much more difficult to arrive at an exact determination of the length of the get-away run owing to the fact that the attitude of the machine may change during the run, and also because the thrust of the propeller varies during the run. For every machine there is undoubtedly a best attitude for the get-away and a best method for attaining the quickest get-away. In the comparative test of the Curtiss HA and R-4-L machines previously mentioned, the tractive resistances were

	HA	R-4-L
With tail-skid dragging, lb.	440	500
With tail-skid set in a two-wheel truck, lb.	240	360

This indicates quite clearly that the pilot should get the skid off the ground as soon as possible and thereby

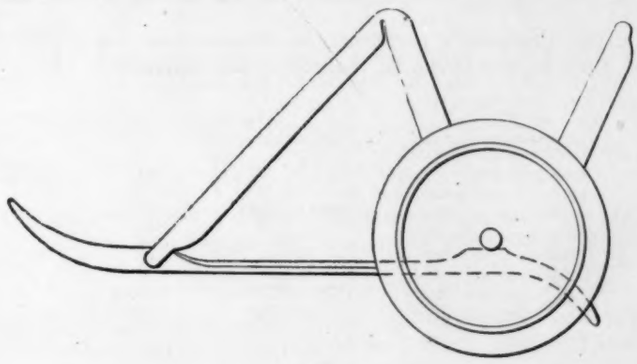


Fig. 8

remove a considerable portion of the tractive effort. Unless the center of gravity is very far back of the wheels, this should be possible almost as soon as the engine is fully effective and the slipstream of the propeller hits the tail surfaces.

When the plane starts off, the equation of motion becomes

$$\frac{W d^2x}{g dt^2} = t - cV^2 - c_3(W - c_2 v^2),$$

The notation is the same as that previously employed and t is the thrust of the propeller. The resistance to movement can be expressed by the formula.

$$(c_1 - c_2 c_3)\, v^2 + c_3 W$$

Since $c_3 W$ is a constant, the acceleration will be a maximum when $(c_1 - c_2 c_3)$ is a minimum. To find the attitude at which this is a minimum, graphical methods are best employed. Taking the HA machine for which the tractive coefficient without skid drag is 0.06, the

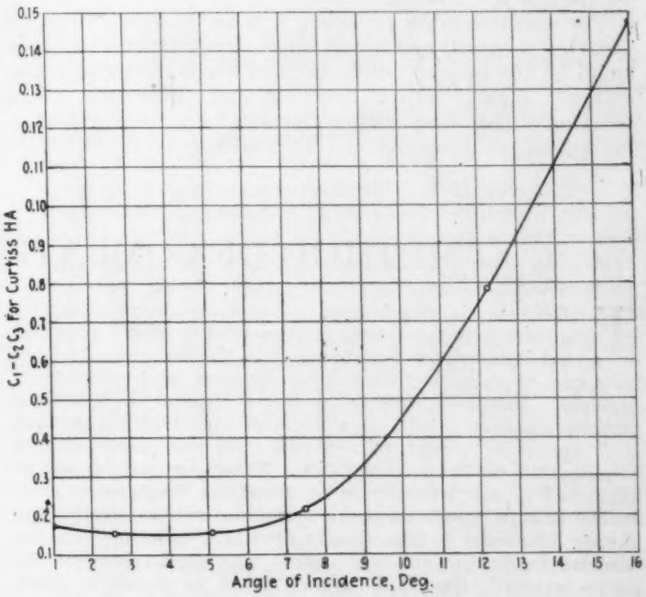


Fig. 9

Curtiss Company's performance computations for a load of 3994 lb. are given in the accompanying table.

PERFORMANCE COMPUTATIONS OF CURTISS HA MACHINE

Speed, m.p.h.	57.5	60	70	80	100	120	125
Angle of incidence, deg.	16.0	12.2	7.5	5.1	2.6	1.3	1.0
Ky for 1 m.p.h. per sq. ft.	0.002460	0.002260	0.001664	0.001274	0.000815	0.000566	0.000522
Wing resistance, lb.	1,140	726	307	247	250	294	307
Parasite resistance, lb.	125	126	162	210	326	469	509
Total resistance, lb.	1,265	852	469	457	576	763	816
c_1 in ft. per sec. units	0.18100	0.10900	0.04420	0.03300	0.02670	0.02460	0.02420
c_2 in ft. per sec. units	0.56200	0.51500	0.37800	0.29000	0.18500	0.12750	0.11800
c_2c_3	0.03360	0.03080	0.02260	0.01740	0.01110	0.00765	0.00710
$c_1 - c_2c_3$	0.14740	0.07820	0.02160	0.01560	0.01560	0.01695	0.01710

Plotting the curve in Fig. 9, it is seen that the minimum value of $c_1 - c_2c_3$ occurs in the neighborhood of 4 deg., at which also occurs the best L/D ratio for the machine. This is what might be expected on general grounds. With the skid off the ground, the tractive coefficient is so low that it will not pay to reduce the reaction on the ground by lifting on the wings. At the same time, if the machine were taken off at too small an angle, the L/D ratio of the wings is too low.

An investigation of the R-4-L machine figures gives a similar result. The computations indicate as correct on theoretical grounds the procedure adopted in a get-away by the best pilots, namely, a quick lifting of the tail and a subsequent run at a small angle of incidence until the flying speed is attained.

The design of the propeller has a certain influence on the length of get-away, although it is difficult to reconcile a propeller working efficiently on the get-away with satisfactory performance in speed and climb. The broad rule for a quick-get-away propeller is to have the diameter small enough so that the engine can attain as high a number of revolutions per minute on the ground as possible, as the thrust increases rapidly with the speed of revolution. Propellers of smaller pitch generally have the larger thrust-power ratio, and wide-blade propellers generally have larger thrust-power ratios also, as indicated in Dr. Durand's tests.

The variable-pitch propeller will be of great value in securing a speedy get-away, since the pitch can be made small on the ground, while in level flight it can be made suitably high. Much practical and theoretical work remains to be done before the full possibilities of the variable-pitch propeller can be realized.

No attempt has been made in the course of this paper to compute the length of get-away. To do this, it would be necessary to know the characteristics of the propeller at low ratios of V/nD and at static thrust, and either to solve the equation of motion by integration for the intervals during which the propeller thrust would be constant, or by putting the thrust into the equation as a function of the velocity. I hope to work out this problem for a typical machine at a later date. The question of the length of get-away offers less difficulties in commercial flying than the landing run, since for the get-away there can be a better selection of ground. In the comparative test on the HA and R-4-L machines, the get-away distances were 538 ft. for the HA and 524 ft. for the R-4-L machine. On the landing run the HA machine was better, owing to the larger angle of incidence than could be maintained in rolling on the ground, but the R-4-L machine made a quicker and shorter get-away because of its lower minimum flying speed.

The Discussion

HARRY E. DEY:—Why not use the reversible engine?

MR. KLEMIN:—You mean and turn the propeller the other way? I suppose it could be done, but it might be a difficult mechanical problem.

MR. DEY:—Take the standard marine engine, used for a great many years, is not that reversible?

MR. KLEMIN:—Yes, I dare say it could be worked out. It probably might be used, but it just would constitute another mechanical device, that is all. The airplane is very free from mechanical devices of any character. The reversible propeller would probably be more useful.

MR. DEY:—It is self-starting, as well as reversible, you know; it means only shifting a camshaft.

METHOD OF COMBATING INDUSTRIAL UNREST

THE Industrial Conference which recently submitted its final report to the President presented therein a program to combat industrial unrest founded on the recognition of the principle of collective bargaining through shop councils if possible. Industries unable to settle disputes within their jurisdiction may appeal to a regional board of adjustment, such appeal to constitute a pledge that the parties to the dispute shall abide by its decision. These regional boards, as suggested in the preliminary report of the Conference, shall consist of nine members, four representatives selected by the parties concerned, a like number of others familiar with the industry in dispute and a chairman who shall represent the public interest. Should a regional board be unable to reach a unanimous decision the dispute may be referred to the National Industrial Board having its headquarters at Washington. The Conference recommended that hours of labor should be fixed "at a point consistent with the health of the workers, there being provision for one day's rest in seven." Other suggestions include a "sincere experiment" along lines of profit sharing and the adoption of measures which will provide adequate schooling for child labor.

Herbert Hoover, vice-chairman of the Conference, stated recently that "just human relationship between employer and employe can be promoted only by deliberate organization." Samuel Gompers in commenting upon the program said that "organization of workers is a fact upon which must be predicated the existence of any machinery for the settlement of disputes. * * * It is to be feared that the Commission views industry from the viewpoint of a single shop * * * on the theory that the disputes are to be settled shop by shop * * * The best economy of the Nation demands that workers be united into organizations covering whole industries."

Flexibility in Organization

By JOHN YOUNGER[1] (*Member*) BUFFALO SECTION PAPER

FLEXIBILITY is defined by Webster as "the quality of being willing to yield to the influence of others; not invincibly rigid or obstinate; responsive to or readily adjustable to meet the requirements of changing conditions." It therefore has a limitation equal only to that set by the definition. If, however, we consider the quality of flexibility as illustrated by a rubber cord stretched in both directions, we readily understand that flexible movement has taken place in two opposing directions, and that if a definite progressive movement is to be made, one end of the cord must be anchored to something rigid. In other words, the only direction in which flexibility of an organization can be considered is that of successful progress. Flexibility uncontrolled is liable to lead to retrogression instead of progression.

I am led to take up this subject as one of the lessons of the war. In that period every available unit of man-power was called into use, and all specialized intelligence was stretched almost to the breaking point. This was particularly true of the intelligence in the automotive industry. Demands were made in connection with the airplane, tanks, agricultural tractor and submarine chasers, as well as the more stabilized automobile and trucks. The most skilful men naturally gravitated to the most difficult work, in the problems surrounding the airplane and the tank, and, while in general there were not nearly enough men, the scarcity of skill was more noticeable in the older branches of the industry. It was there that the necessity for a flexible organization demonstrated itself.

The first necessity was a rigid base from which progress could be made. This was found in the accumulated data of the industry and in the experience of our automotive engineers. These data became our standards, our starting points. Incidentally, in this connection I learned the one big truth about standards and standardization. Standards must not be made to express finality, as they so often are. They must, on the contrary, be looked upon as starting points or milestones, measuring progress. I believe that the arguments for and against standardization are based upon the viewpoints expressed, and not so much upon the statements of standards.

We began in the Motor Transport Corps with as much accumulated data as possible, and this information was concentrated in what was called the planning section, although it was really a miniature of the General Staff of the Army. The men composing this group sought out information, analyzed, digested and passed it along in concentrated form to what can be called the operative section of the Engineering Division. In other words, we applied in an engineering organization the principle of the machine-shop routing department. This principle can and must be applied in any manufacturing organization, if it wishes to maintain its flexibility and elasticity in these days. The value of a planning department in a machine shop is obvious. Even a small railroad must have its planning or dispatch-board system to insure schedule running. Under present-day conditions, the same idea must be carried higher and higher up, to ensure permanent results.

EDUCATION A NECESSITY

We are fully alive to the meaning of labor turnover and to the advisability of keeping it low, to conserve the sum total of our existing experience. We are just now awakening to a full realization of the value of increasing the store of knowledge in this connection by the education of our men. It is only a step further to consider the education of our organization. An organization is like a large tank, at first partially filled and being drained somewhat by its percentage loss of labor, but being at the same time refilled by the influx of new labor, with resultant slight changes in level. The tank can be filled only by adding something new; the level can be made flexible in an upward direction by the addition of what?

From the human side this has an interesting angle. It might be expressed mathematically by stating that the summation of experience gained or lost is nil when a man's experience is transferred from one organization to another exactly similar; whereas, if his experience is transferred from one industry to a totally different industry, this will in all probability contribute to flexibility in the direction of progress. I am asking you to be flexible in your thoughts, and not hide-bound by convention and what has gone before.

Another of my lessons from the war is that I will, in the future, rarely turn down a man for lack of experience in some particular line. I feel that, in the majority of work, the ability of any man depends not entirely upon his previous experience. It depends also upon his ability to pick up work, to apply certain fundamental principles, to study the work and bring a fresh viewpoint to bear upon it, so that actual progress will have been made at last.

Washington authorities were criticised severely during the war for placing men in so-called impossible situations. Unfortunately, there were many cases of round pegs in square holes, but there were just as many cases, if not more, of men who did not know from past experience that some particular thing was practically impossible, and therefore went ahead to accomplish it. I can cite one case of a man who had been for many years a professor of law at a Middle West university, being put in charge of important engineering work. He was deliberately selected for this work because of his character, training and ability to handle specific details in a way whereby a minimum of time was consumed in getting action. His new viewpoint and insistence upon completion of detail insured accuracy and time saving in handling the long distance work that had to be done. I was once told that the value of education lies in the fact that it enables a man to pick up an idea more quickly than the boss can find out how little he knows about it.

I believe we are on the eve of as great a labor shortage as we have ever experienced, a labor shortage which is still further emphasized by a housing shortage and in which not only will there be insufficient

[1]Vice-president, Standard Parts Co., Cleveland.

skilled labor available but also insufficient skilled intelligence. New viewpoints must be brought to bear upon the problems confronting us. Our minds must become more flexible; they must not remain quiescent, but expand under changing conditions.

Let me indicate some of the more delicate points of human inertia. It is difficult to know what to do with the old, rooted notions in a business; the practice of making old men saints is pursued at the expense of the new, young blood pushing its way upward, finding that this type of organization is too inflexible, too rigid to accommodate it. Youth eventually has its way, but often at an expense that is frightful. Is it possible to so proceed as to overcome our human inertia and become flexible enough to assimilate new ideas and incorporate them into constant progress? The formation of research bureaus, even if a bureau consist of but one man engaged part time in other work, will help tremendously in keeping in touch with the world's progress. The value of this idea has so proved itself during the war that Great Britain has appropriated millions of dollars to further new ideas. In our own country the more important engineering societies have united for the purpose of furthering research. The larger manufacturers, appreciating the success of the General Electric Co. in this direction, are following its example. Thus the search for knowledge is now in progress. Nor is research confined exclusively to matters of science. The problems of employment, industrial relationships and the broad field of sociology are now under the microscope and rapidly being developed into science.

The Present, an Age of Specialization

The underlying thought in this paper is that, more than ever before, this is a period of intense specialization, with everything tending to fit us, like bricks, into a narrow standardized world. The skilful architect may take these bricks and build with them edifices that express his individuality, but for the great mass the unit expresses the ultimate, and the ideal there is expressed by maximum and minimum tolerances imposed by custom. I often wonder why we take such pains to educate our children in the mass. They not only learn the fundamentals but also all kinds of what we call "fancy stuff." We send them through the high school and further instill into them all kinds of mathematics, science, biology, psychology and the like. Then, still in the mass, they are turned out into a cold world where some manufacturer employs them to turn out some highly specialized machine part, after a few weeks' intensive shop course. Whether it be in machining automobile parts or in selling ribbons over a counter, specialization rules.

I wonder, however, if we cannot make work more flexible by what might be termed a ruse. For example, labor leaders are calling for a seven-hour day; the eight-hour day is already granted. Yet in Detroit in a plant where the men work the actual net eight-hour day, I am told that large numbers of them go to another plant and work another eight hours. In effect, these men have realized that the problem of the shorter working day is not so serious as the problem of their idle or leisure time. Is there not food for thought in the problem of changing the nature of work, to prevent fatigue and dullness, and fill the present leisure or idle period with productive work? Many have worked long past the time-clock hour at something which interested them greatly. There can be intense pleasure in keeping strenuously at some task that is actually a hobby. The thought is to make our jobs and the jobs around us interesting by encouraging the human aspect of them so that we shall see more than the specialized function.

Flexibility is tremendously important. In an organization it expresses such breadth that I have only been able to touch upon the more obvious points. The last 100 years have witnessed tremendous progress in mechanical science. I feel that we are on the eve of a century of years that will be crowded with a similarly human and sociological progress.

COMMODITY PRICES

THE three main elements in commodity prices are the *real* cost of production, transportation and distribution, the relation of supply to demand and the scarcity or abundance of the various media of credit and exchange. The curve of index numbers of composite commodity prices, while showing many fluctuations, has maintained a general upward trend throughout the period during which such numbers have been compiled. Had it been possible, however, to have an absolute standard of costs, a standard, for example, which would represent the sum total of human effort, direct and indirect, which had been expended upon the commodities, it can hardly be doubted that the curve of composite commodity costs would have shown a constantly downward trend; for the period during which index numbers have been compiled has been one of constantly increasing application of machinery to every stage of production, transportation and distribution. Furthermore, it cannot be assumed that the general upward trend of commodity prices has been due to any progressive reduction in the ratio of supply to demand. If this is correct, the upward trend is primarily due to a more rapid increase in the media of exchange, coin, currency and credit instruments, than in the production of commodities.

This conclusion is most apparent when we consider the periods of extreme financial inflation which characterize the prosecution of great wars. During the years 1861 to 1865 wholesale prices increased 116 per cent and in 1874 were still 33 per cent higher than before the war. The Civil War cost $3,500,000,000 and materially affected one nation only. The present war has unsettled the financial structure of the entire world. The United States alone in the four years, 1914 to 1918, increased its gold reserve 200 per cent and expanded its credit instruments in the form of demand deposits and notes by $6,600,000,000. It has also issued bonds aggregating $21,400,000,000. The belligerent nations, exclusive of Russia, have increased their note circulation 447 per cent, while the total cost of the great conflict is estimated to have exceeded $200,000,000,000. If the deprceiation in the value of the dollar was still felt fifteen years after the outbreak of the Civil War, what shall we expect from a war that has cost ten times more than all the other wars waged in the world during the last seventy years.

The primary cause, now and for many years to come, of the depreciation in the purchasing power of the dollar is and will be financial inflation. Furthermore, the possibilities of additional credit expansion through the use of the huge volume of outstanding Government bonds and the probable flotation in this country of foreign securities for European reconstruction are likely, at the least, to offset any immediate appreciation in the dollar that might otherwise be brought about by an increase in production.—From an address recently delivered by O. C. Merrill before the American Association of Engineers.

Flying an Airplane Engine on the Ground

By S. W. Sparrow[1] (*Member*)

Aeronautic Meeting Paper *Illustrated with* Charts

In the early part of the war there was much dissatisfaction with the existing methods of testing airplane engines. The very complete laboratory tests made at ground level were of little aid in predicting performance with the reduced air pressures and temperatures met in flight. On the other hand, it was well-nigh impossible in a flight test to carry sufficient apparatus to measure the engine performance with anything like the desired completeness. The need was clear; it was to bring altitude conditions to the laboratory where adequate experimental apparatus was available; in other words, to fly the engine on the ground. To make this possible, the altitude chamber of the dynamometer laboratory at the Bureau of Standards was constructed.

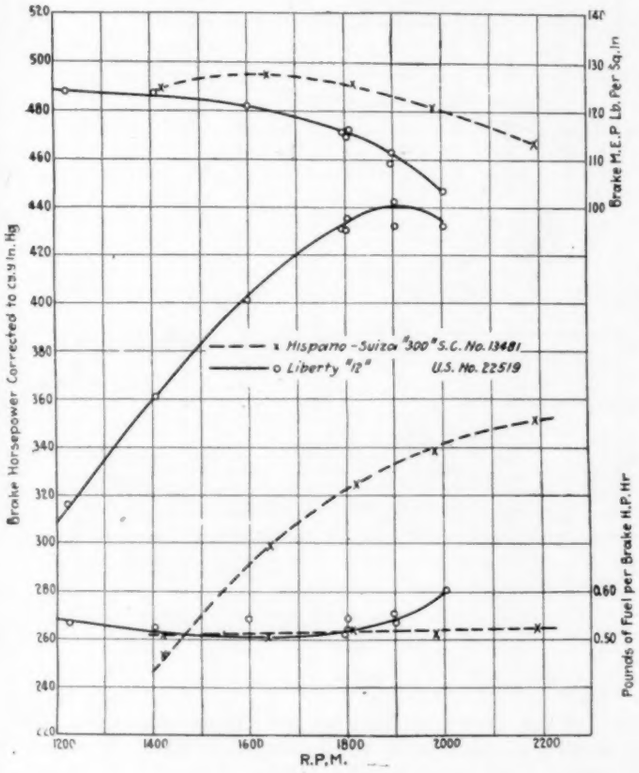

Brake Horsepower Corrected to cs.g In. Hg
Brake M.E.P Lb. Per Sq. In
Pounds of Fuel per Brake H.P. Hr
x Hispano-Suiza "300" S.C. No. 13481
o Liberty "12" U.S. No. 22519
R.P.M.

Fig. 1

The work here naturally divides into two general classes. The first aims to determine how good the engine is; the second, how it can be made better. The latter class includes research and development work; from its nature, any program for such work must be flexible. This by no means implies the absence of a definite plan of procedure but rather recognizes that the completion of one step is necessary to determine the line to be followed in subsequent investigations. Moreover, this class of work should respond quickly to each need of the industry or, better yet, it should anticipate these needs. Work of the first class, on the contrary, is essentially dependent upon a program that is fairly well fixed. It is strictly work of measurement, comparing the performance of one engine with that of another, or with some predetermined standard. This requires decisions as to what measurements are most necessary, what standards are most suitable. Nor should it be forgotten that a Government laboratory should serve the industry of the whole nation, and that the value of any program of tests lies in the degree in which it furnishes the information that the industry requires. It is to call attention to some of these requirements that this paper is presented.

Standard Comparative Engine Tests

Obviously, comparative tests of engines may be as diverse in nature as are the questions such tests seek to answer. It should be possible, however, to outline a standard program which will provide a reasonably satisfactory basis for predicting the engine's value for a given service, and yet not consume so much actual running time as to prohibit tests upon the same engine in that service. From recent experiments made at the Bureau with a Hispano-Suiza and a Liberty engine, there have been selected those runs which seem most properly to belong to such a program.

These include

(1) Full-power runs at ground altitude over speeds ranging from 1200 to 2200 r.p.m.

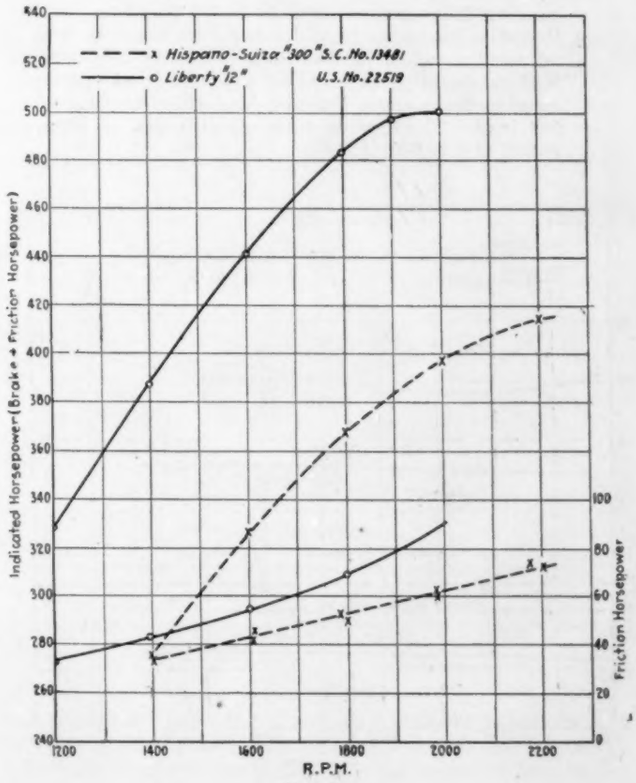

Indicated Horsepower (Brake + Friction Horsepower)
Friction Horsepower
x Hispano-Suiza "300" S.C. No. 13481
o Liberty "12" U.S. No. 22519
R.P.M.

Fig. 2

[1]Associate engineer, Bureau of Standards, Washington.

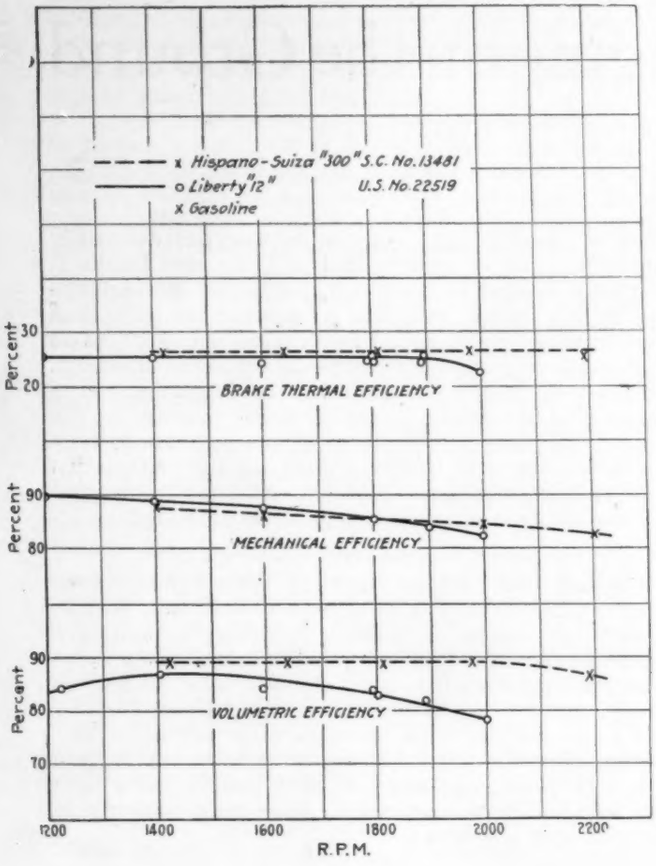


FIG 3

(2) Full-power runs at two speeds and at altitudes ranging from ground level to 25,000 ft.

(2) Propeller-load runs in which the dynamometer was adjusted so as to produce approximately the same load as would be imposed by a propeller at speeds ranging from about the half-load speed to that of full load. These were made at altitudes of 5000, 10,000 and 15,000 ft.

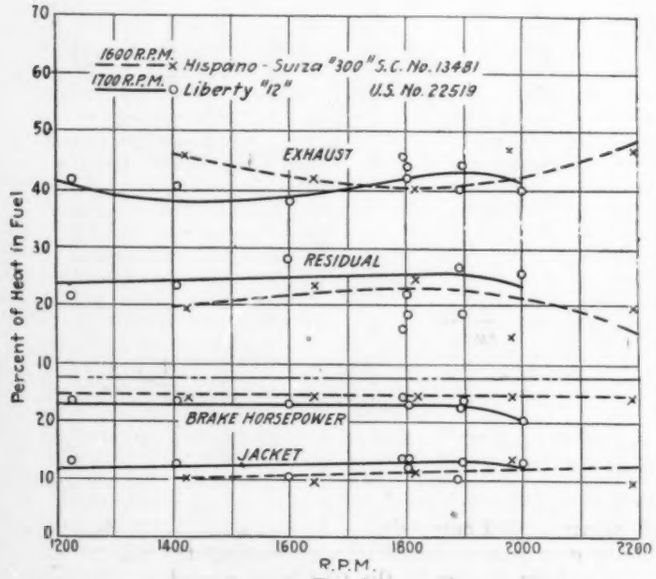


FIG. 4

(4) Friction-horsepower runs in which the engine was driven by the dynamometer. These were made over the same speed range as the first series and at ground level and an altitude of 15,000 ft.

To the engineer, appreciative of the value of essentially reproducing service conditions in test work, the first series of observations may appear ill advised in that it subjects the engine to conditions unlikely to be met in practice. Justification for the full-power ground runs lies in the ease with which they can be duplicated with the equipment available at most laboratories and flying fields. This test then serves in a measure as representa-

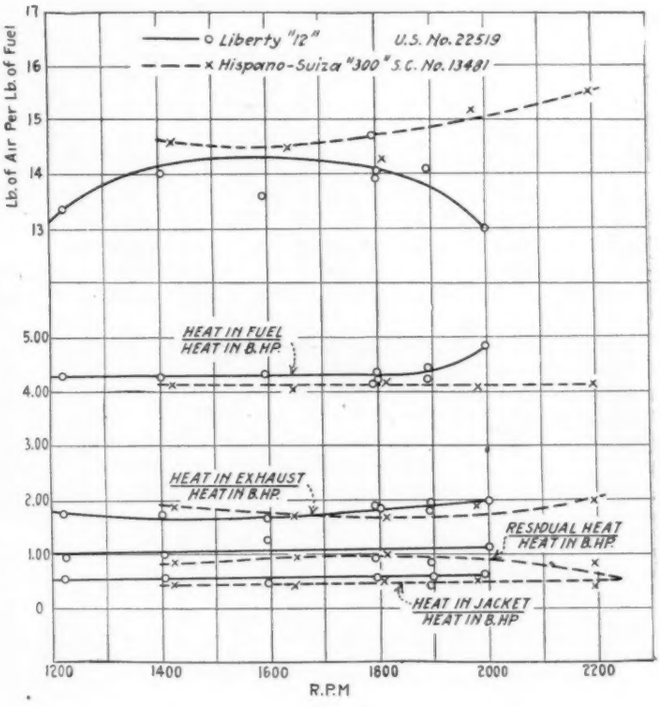

o Liberty "12" U.S. No. 22519
x Hispano-Suiza "300" S.C. No. 13481
HEAT IN FUEL / HEAT IN B.HP.
HEAT IN EXHAUST / HEAT IN B.HP.
RESIDUAL HEAT / HEAT IN B.HP.
HEAT IN JACKET / HEAT IN B.HP.
Lb. of Air Per Lb. of Fuel
R.P.M

FIG. 5

tive of the series, so long as an engine can repeat its previous performance on the ground it is likely to repeat its previous performance at altitude. The altitude power runs are perhaps the most important of all, inasmuch as they show directly the effect of changes in altitude upon the full-load performance of the engine. The propeller load shows primarily the influence of carbureter and inlet-manifold characteristics upon fuel consumption, while the friction runs give information necessary in the determination of mechanical efficiency. Some of the most important results of these tests are presented graphically in the accompanying figures. Since results and not methods are of vital importance, it is by the study of these results that the value of the foregoing series of tests can best be gaged.

CURVES OF TEST RESULTS

Figs. 1 to 4 are based upon the ground runs. Their purpose is clear. Expressing it, in its simplest form, the brake-horsepower curve tells what the engine can do, and the fuel consumption curve tells the price it exacts for doing it, while the brake mean-effective-pressure curve furnishes a measure of performance from which the size of the engine has been eliminated. Friction horsepower measurements show the power expended in overcoming

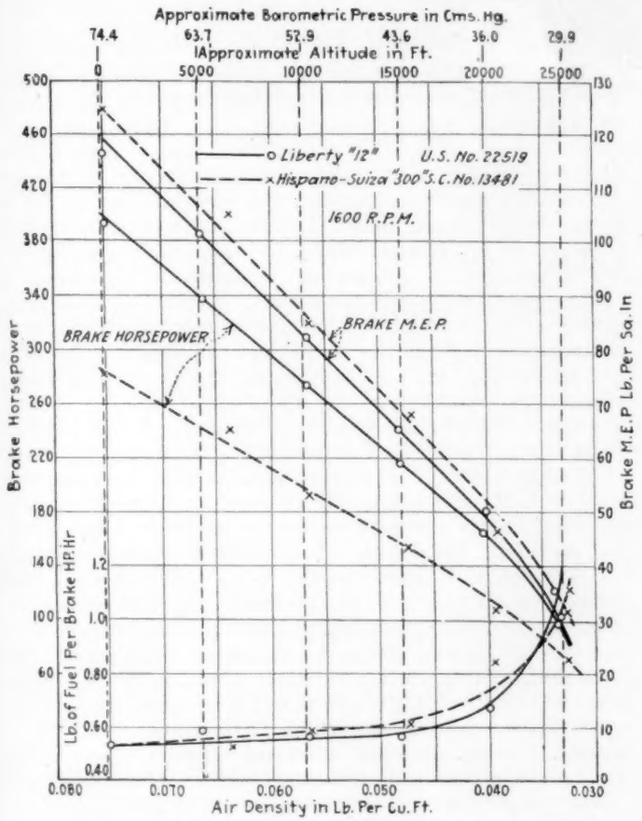


FIG. 6

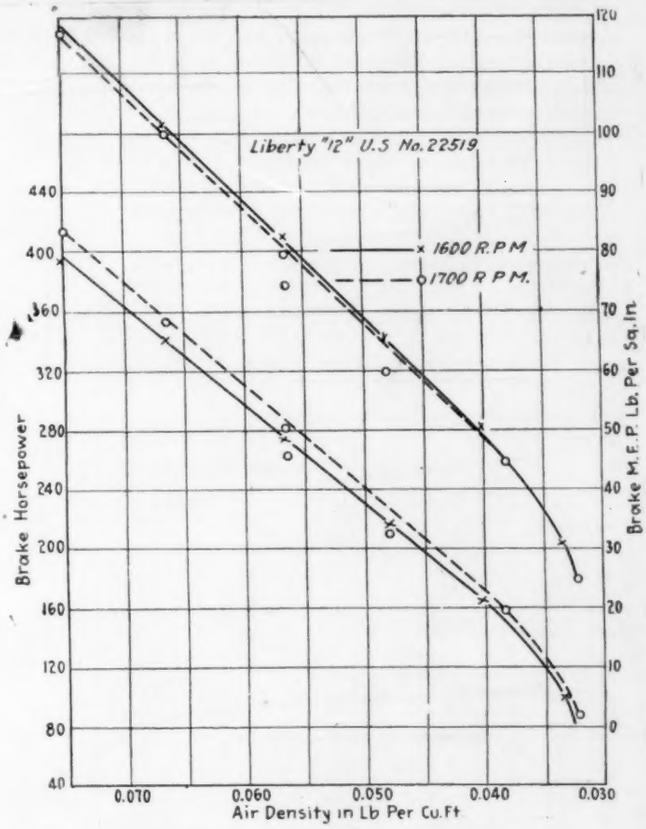


FIG. 8

internal friction and pumping losses. Adding these to the brake horsepower gives the quantity termed indicated horsepower, the approximate power developed in the en-

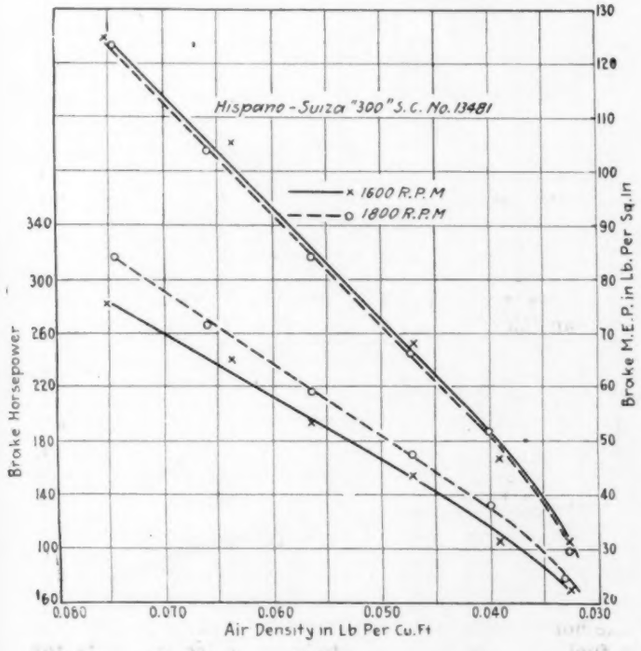


FIG. 7

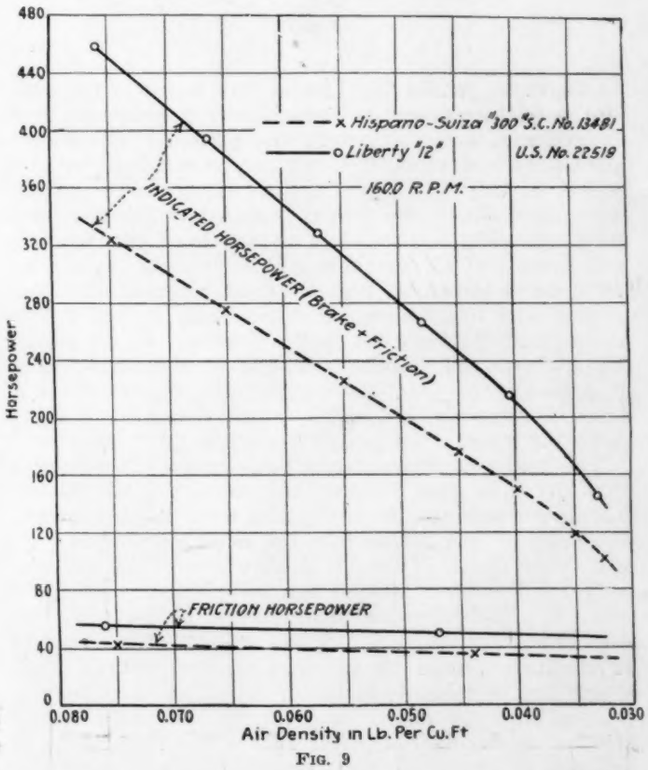


FIG. 9

gine cylinders. This measurement often explains the superiority of one engine over another, although it is always by the brake-horsepower measurement that such superiority is first determined. In Fig. 3 the usual efficiencies are given, namely thermal, expressing the degree to which the heat energy in the fuel is converted into brake

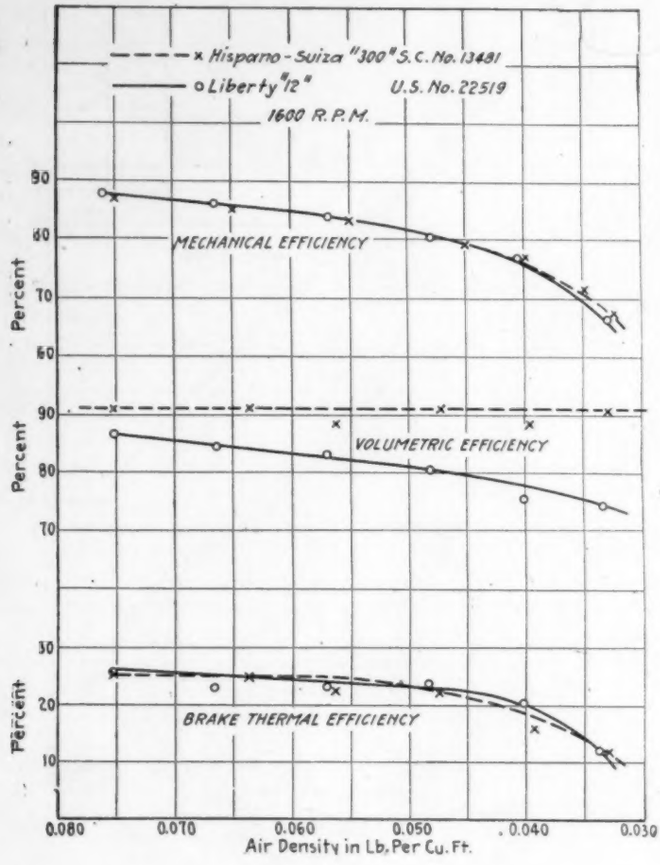


FIG. 10

horsepower; mechanical, giving the degree with which the power developed in the cylinder appears as brake horsepower, and volumetric, the pumping efficiency of the engine in drawing in its charge. A complete report of a test of this sort would include many curves omitted here, since they serve primarily as intermediate steps in locating others. Thus, plots of pounds of fuel per hour and pounds of air per hour aid in locating the air-fuel ratio curve shown on Fig. 4. Heat balances have been plotted with brake horsepower as a base, as well as with the conventional base, the heat in the fuel. To the designing engineer, the former method is of advantage in that it presents the heat distribution directly in terms of brake horsepower, a quantity which forms the starting point for much of his design work.

The brake horsepower and brake mean-effective-pressure given in Fig. 1 have been converted to standard barometric pressure by multiplying the original values by the ratio of this pressure to the pressure at which the tests were made. To avoid making corrections for temperature, whenever possible this series of runs should be made at a predetermined temperature, 15 deg. cent. (59 deg. fahr.) for instance. In any event, a record of the temperature should be included in the report. Care should also be taken to maintain the oil and jacket-water temperatures as nearly as possible the same during friction as during the power runs. The importance of this and of recording these temperatures was made evident in a recent test where lowering the jacket-water temperature from 50 to 40 deg. cent. (122 to 104 deg. fahr.) increased the frictional losses 8 per cent with one grade of oil and 5 per cent with another.

Omission of Temperature Runs

Altitude and propeller-load results are given in Figs. 5 to 14. Figs. 7 and 8 are included merely to show how the observations at two speeds serve as checks upon each other and aid in locating the curves. There is considerable controversy as to whether results should be plotted against air pressure, air density, or altitude. Density seems most logical since, other conditions being equal, it is the weight of the charge that determines the power. Unfortunately, a change in temperature produces a change in power, whether density or pressure be held constant. This discussion is, however, of secondary importance, since it applies only to the expression of results and not to the conditions under which they are obtained. Much more pertinent is the query as to whether or not actual conditions shall be simulated to the extent of lowering the carbureter air temperature with each increase of altitude. Such a procedure was followed on these two tests, but it is questionable if this course is generally desirable. Any analysis of results is made difficult by the fact that the effects of changes in carbureter air temperature are superimposed upon those due to the changes in air density. Furthermore, the different temperature for each altitude makes changes from a pressure to a density base or vice versa decidedly cumbersome. If it be decided to maintain a constant carbureter air temperature, the next step is to select a temperature. Here again a considerable departure from actual conditions, namely, making the observations at a temperature somewhat above 0 deg. cent. (32 deg. fahr.), seems justified. Lower temperatures, through the resulting poor vaporization, freezing of carbureter air bleeds, etc., persistently cause erratic engine performance and uncertain compari-

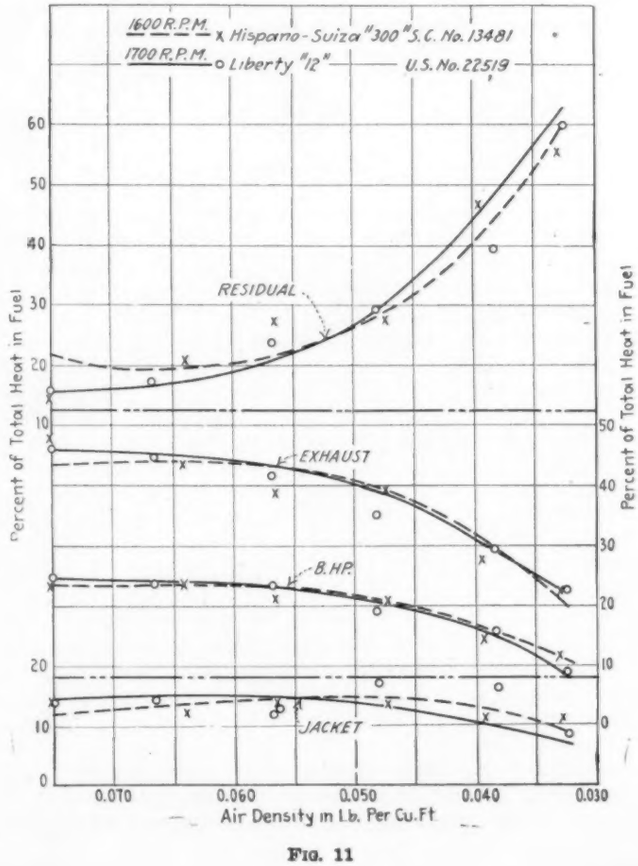


FIG. 11

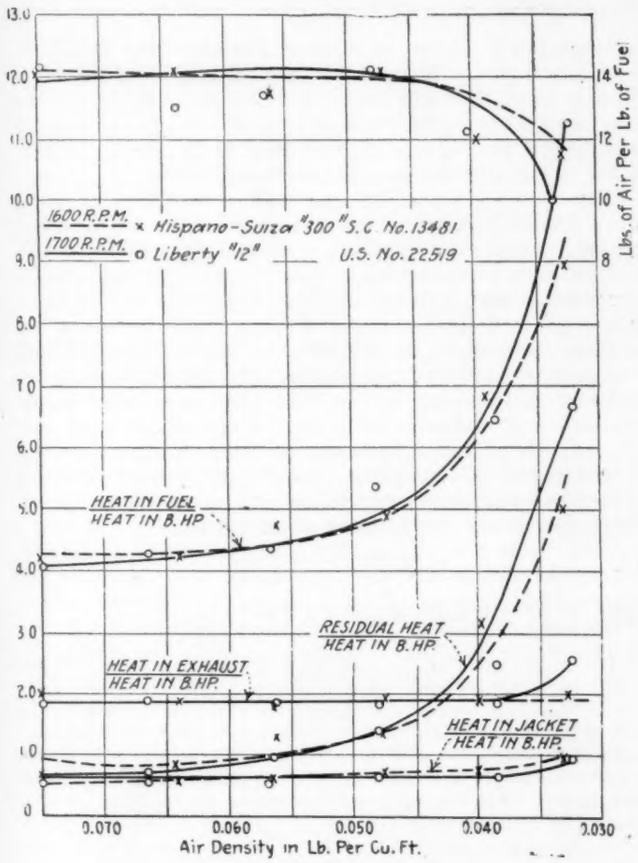

1600 R.P.M. x Hispano-Suiza "300" S.C. No. 13481
1700 R.P.M. o Liberty "12" U.S. No. 22519
HEAT IN FUEL / HEAT IN B.HP.
RESIDUAL HEAT / HEAT IN B.HP.
HEAT IN EXHAUST / HEAT IN B.HP.
HEAT IN JACKET / HEAT IN B.HP.
Lbs. of Air Per Lb. of Fuel
Air Density in Lb. Per Cu. Ft.

FIG. 12

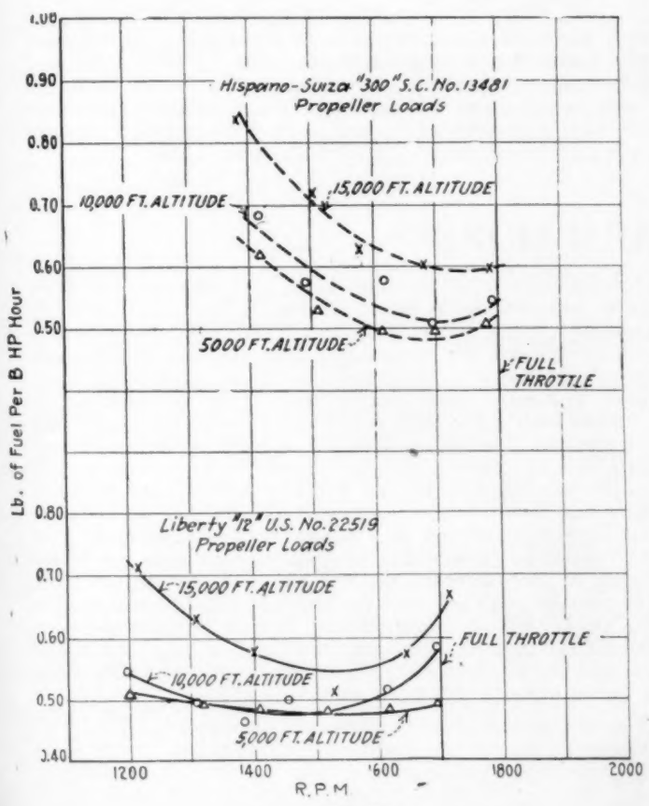


FIG. 13

sons. Rating an engine upon such performance seems hardly fair, since it is usually the carburetion that is at fault, and the exact nature of the fault is difficult to determine. On the other hand, it may be pointed out, with good reason, that it is decidedly advantageous to make the run at a low temperature in order that such troubles may be appreciated, even though the value of the engine comparison suffers in consequence. Perhaps the best solution for the present would be to make the runs at one speed at the high carbureter air temperature and the other speed at the low temperature, in both cases maintaining the temperature the same at all the altitudes. It is possible that this question will in time disappear through a generally followed tendency to pre-

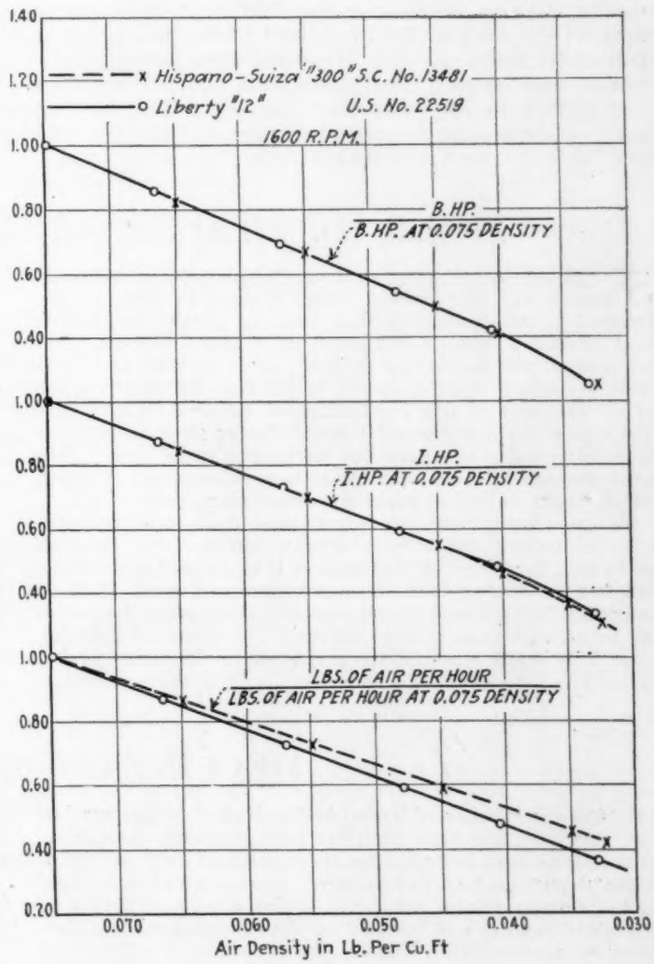

x Hispano-Suiza "300" S.C. No. 13481
o Liberty "12" U.S. No. 22519
1600 R.P.M.
B.HP. / B.HP. AT 0.075 DENSITY
I.HP. / I.HP. AT 0.075 DENSITY
LBS. OF AIR PER HOUR / LBS. OF AIR PER HOUR AT 0.075 DENSITY
Air Density in Lb. Per Cu. Ft.

FIG. 14

heat the carbureter air to a point above this troublesome range. I am of the belief that the gain in power from the use of air at extremely low temperatures scarcely ever compensates for the uncertain operation that usually ensues.

The foregoing remarks explain to a certain degree why temperature runs have been omitted. These are made for the purpose of finding how much a change in carbureter air temperature affects engine performance. This requires several carbureter settings at each temperature as, otherwise, slight changes in mixture ratio will produce differences in performance for which the temperature change is by no means responsible. When

an engine is in production, one of the type should be subjected to such a test, but the running time required is so great as to prohibit its inclusion in the program under consideration.

Decrease in Power at Altitudes

It is of interest to note in Fig. 14 that in spite of the marked differences in construction between the Hispano-Suiza and the Liberty engines, the percentage decrease in both brake and indicated horsepower is the same for both engines at altitudes up to 20,000 ft. and an air density 0.040 lb. per cu. ft. Above this altitude the carbureter adjustment was inadequate, so that the curves are influenced by the over-rich mixture as well as by the density change. Carbureter characteristics, to a large extent, fix the form of the propeller-load curves of Fig. 13. Durability tests, analyses of weight distribution, inertia forces, bearing loads, etc., have been omitted, not from any failure to recognize their value but because such work is not dependent upon the equipment necessary for altitude tests. It can be done at any time and at almost any laboratory. That these tests did not constitute a serious drain upon the life of the engines is evident from the fact that the total running time of the Liberty engine was about 11 hr. and that of the Hispano-Suiza about 5 hr. This includes the "warming-up" time.

The value of carrying out such a program of tests upon a large number of engines can scarcely be overestimated. To the Government, accurate knowledge of the performance of such powerplants is especially valuable in the event of war. To the manufacturer, such tests always prove an incentive to better design. Nor is this work without its value to the research engineer. Knowing that one engine is better than another, the difference between the engines furnishes a suggestion at least as to where to search for points of superiority. Above all, it must not be forgotten that in laboratory tests engine failures seldom result in loss of life. Surely this will not be overlooked by an industry which has owed so much of its development to the fearlessness of its pilots.

THE RADIO TELEPHONE IN CHASSE SQUADRONS

SINCE the inception of radio communication between airplanes and the ground, which started in 1916, at San Diego, Cal., when Colonel, then Captain, Culver successfully sent messages from a Wright-Martin plane, wireless communication has made vast strides. Even at that early date it was realized what a source of possibilities were capable of development in this application of wireless to airplanes, and under the direction of Colonel Culver steps were taken to develop and standardize the equipment to be used. Then came the war with its consequent large allowances of funds, which meant unlimited experimentation along radio lines.

The war being over, the Air Service finds itself equipped with just about the most practical, compact and complete radio sets for airplane installation that present-day science can devise. Among these is the set known as the S. C. R. 73 which the De Haviland planes now operating along the border are using with such marked success. To quote Colonel Culver, "This set is the best telegraph set in the Army and is practically fool-proof." It consists of a streamline generator in the housing of which are, in addition to the generator windings, a rotary spark-gap, a power transformer and condenser and an oscillation transformer. The generator is driven by a variable-pitch aluminum propeller which maintains a constant speed of 4500 r.p.m. This set is capable of sending messages over 100 miles when properly operated and maintained. An average performance of 50 to 75 miles can always be relied upon.

On the chasse airplanes of the First Pursuit Group two kinds of radio instruments are installed in the S. E. 5's. The telegraph is not used at all, dependence being placed upon the wireless telephone. There are at present in every squadron of the First Pursuit Group three planes equipped with the radio telephone. One of these planes is equipped with a simple receiving set, the S. C. R. 59. The other two planes of the squadron are equipped with the S. C. R. 68, which is a two-way set, capable of transmitting or receiving the voice a distance of from 3 to 10 miles, with an average radius of 3 to 6 miles.—Air Service News Letter.

DECLINE OF FARM HORSES

IN 1913 the number of horses in the United States reached a maximum and since then has been gradually decreasing, according to data compiled by the bureau of crop estimates of the Department of Agriculture. The information secured by the Bureau relates primarily to the supply of horses on farms and ranches and is based upon a survey recently undertaken by approximately 36,000 crop reporters in all sections of the country. These have reported the names of more than 49,000 farmers employing motor trucks on their farms. The use of motor vehicles does not necessarily mean that horses have been actually displaced, as in many cases the introduction of a truck on a farm indicates provision for increased hauling rather than an actual reduction in the number of horses kept.

The estimated number of horses on the farms and ranches of the country on Jan. 1, 1920, was 21,109,000, a decrease of 373,000 animals or 1.7 per cent compared with a year ago. The total value of these animals is estimated at $1,992,542,000 as against $2,114,897,000 last year. The average value per head for horses of all ages on Jan. 1, 1910, was $108.03. This figure had declined to $98.45 on Jan. 1, 1919, and to $94.39 on Jan. 1, 1920. In addition to the increased use of motor vehicles the greater demand for feed for high-priced meat animals in the past two years has made it relatively more costly to keep a horse on the farm. The best demand in 1919 has been in the Southern States while the decreases that are reported have occurred on the extensive ranges which occupy such a relatively large portion of the Western States.

Although the number and value of horses have declined, there has been a slight increase in the number of mules in this country compared with a year ago. The prosperity of the Southern States where most of these animals are is reflected in the increased demand and the high prices paid. The average price per head for mules of all ages was $147.10 on Jan. 1, 1920, as compared with $135.83 the year previous and $120.20 in 1910. The total number of mules on the farms and ranches the first of this year was 4,995,000, an increase of 41,000 animals or 0.8 per cent.

Maintaining Airplane Engine Power at Great Altitudes

By Lieut.-Col. V. E. Clark[1] (*Member*)

Aeronautic Meeting Paper *Illustrated with* Charts

In the summer of 1917, the Bolling Airplane Mission to Europe recommended in an official report that our engineers direct especial energy toward the development of means to maintain a high proportion of the power of airplane engines at great altitudes. Some very creditable work has since been done by at least two engineers as a result of this suggestion, and a recent flight test at an altitude of 20,000 ft. indicates a resultant marked increase in airplane performance. It is felt, however, that interest in this development should extend to more of our engineers. The purpose of this paper is therefore to indicate the possibilities and limitations of increasing airplane speed by introducing means to maintain high engine power at great altitudes. I have attacked the problem by selecting the DeHaviland-Four as being an airplane typical of present practice, and by endeavoring to compute approximately the performances that might be obtained at different altitudes with various assumed ratios of the actual engine power at the altitude to the total weight of the airplane in every case.

The accompanying series of curves giving the values of the various coefficients results. Airplanes of greater aerodynamic efficiency, resulting for instance from the elimination of exposed wires, struts, wheels and the like, without sacrificing airfoil efficiency, would, of course, have greater speed for the same power-weight ratios. The method by which the values of the coefficients were obtained will be of assistance in reading and applying the charts. All values are based upon results obtained from full-scale flight computations and not solely upon wind-tunnel tests.

δ = relative density of air
P_h = actual horsepower developed by the engine at the altitude assumed
P_o = engine power at sea level
W = the total weight of the airplane in pounds, when leaving the ground
S = surface loading or the total weight of the airplane in pounds divided by the net square feet of area of the main planes, including flaps
e = the propeller efficiency under the conditions assumed. This usually varies from 0.70 to 0.80 throughout the range of working speeds of advance and of revolution
V = the velocity of the airplane through the air in statute miles per hour. Because of winds, V has no relation to the speed of the airplane with respect to the ground. Unless otherwise noted, V is the *maximum possible horizontal air speed*
A = the net area in square feet of the main planes, including flaps
T = the propeller thrust in pounds per square inch
C = in general, any coefficient whose value varies with the angle of incidence

The notation employed throughout the paper is given at the bottom of the preceding column.

In steady horizontal flight

Fig. 1 shows an approximate curve of relative density plotted against altitude. When consulting this curve, it must be borne in mind that the portion of the curve above 30,000 ft. is entirely conjectural and must only be considered as very approximate. A more exact method of computation would be to deal with values of density only,

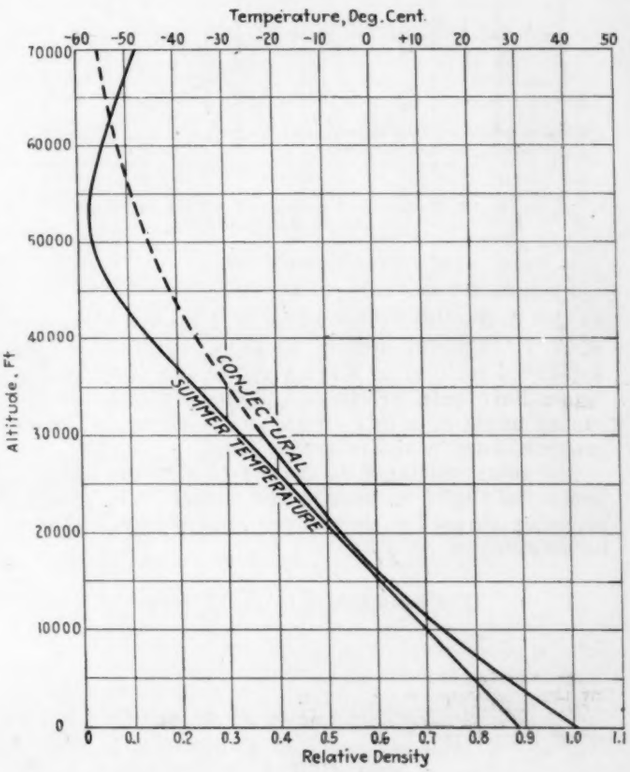


Fig. 1

not considering altitude. Should means be developed for rising to great altitudes, further meteorological data as to densities, temperatures, wind velocities, etc., during various seasons and in various latitudes, will directly become necessary.

$$mg = W = \text{total lifting force} = C\delta AV^2, \text{ hence}$$

$$\frac{W}{A} = S \text{ or, } S = C\delta V^2$$

$$V = C_1\sqrt{\frac{S}{\delta}} \text{ or, } C_1 = \sqrt{\frac{\delta}{S}} \qquad (1)$$

Values for C_1, for any airplane geometrically similar

[1] Engineering division, Air Service, Dayton, Ohio.

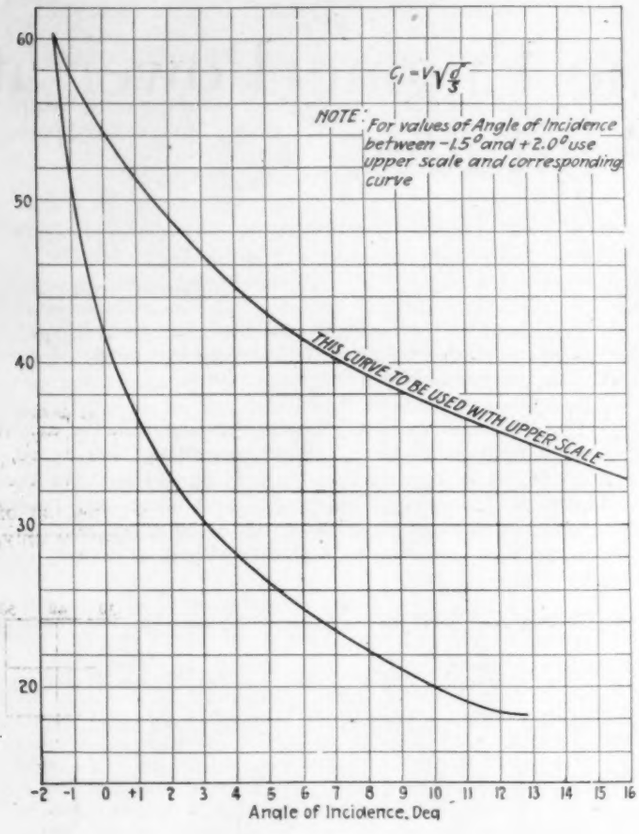

$C_1 = V\sqrt{\frac{\delta}{S}}$
NOTE: For values of Angle of Incidence between −1.5° and +2.0° use upper scale and corresponding curve
THIS CURVE TO BE USED WITH UPPER SCALE
60
50
40
30
20
-2 -1 0 +1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Angle of Incidence, Deg

FIG. 2

to the DeHaviland-Four which is a tractor biplane with R. A. F. 15 airfoil section, an aspect ratio of ± 7 and a gap-chord ratio of ± 1 are given in the curve in Fig. 2. These have been arbitrarily plotted against the values of the angle of attack of the main planes. The mean tangent chord is the reference base.

The total resistance of the air to airplane advance in horizontal flight, in pounds per square inch, equals the propeller thrust in pounds per square inch if there is no acceleration or, $C_2\delta AV^2$.

$$T = \text{resistance} = C_2\delta\frac{W}{S}V^2, \text{ hence} \qquad (2)$$

$$C_2 = \frac{ST}{\delta WV^2}$$

The engine horsepower required to generate the propeller thrust is

$$\frac{C_2\delta WV^3}{375\,S\epsilon}$$

$$P_h = \frac{C_2\delta WV^3}{S\epsilon}, \text{ hence} \qquad (3)$$

$$C_2 = \frac{P_hS\epsilon}{\delta WV^3}$$

Values for C_2 for machines geometrically similar to the DeHaviland-Four are shown in Fig. 3. The character of the curve of C_2, for parasite resistance with slipstream, changes, of course, with any variation in the propeller pitch or the air speed. Values for C_2, for the same type, are shown in Fig. 4. For airplanes in which the proportion of total area of cross-section of fuselages to area of main planes is greater than in the case of the DeHaviland-Four, the proportion of C_2 and C_3 for parasite resistance will be higher and vice versa.

Referring to Fig. 3, it is interesting to note that the theoretical limit of diving speed of the DeHaviland-Four is, with an angle of incidence of — 1.0 deg.

$$\sqrt{\frac{S}{0.000109\,\delta}}$$

Or, if the wing loading equals 9 lb. per sq. ft., the diving speed equals 287.2 m.p.h. at sea level. This is not exact. For a vertical dive, the angle of incidence is that giving zero lift and the drag coefficient is higher than the minimum. On the other hand, if the drag coefficient is the minimum, there is some lift, the drag is less than the weight and the dive is not quite vertical.

The gliding angle, referred to horizon, with no power, is

$$\tan^{-1}\left(\frac{C_2\delta V^2}{S}\right), \text{ hence}$$

$$V = C_1\sqrt{\frac{S}{\delta}} \qquad (4)$$

At an 8-deg. angle of incidence, at sea level, the wing loading equals 7.5 lb. per sq. ft., minus V (see Fig. 2), equals 60.9 m.p.h. The gliding angle (see Fig. 3) equals 1÷8.6 or 6 deg. 39 min.

From equation (3) we derive

$$\frac{W}{P_h} = \frac{S\epsilon}{C_2\delta V^3}, \text{ or } V = \sqrt[3]{\frac{P_hS\epsilon}{C_2W\delta}}, \text{ but} \qquad (5)$$

as equation (4) gives a value for V, we obtain

$$\frac{W}{P_h} = \frac{\epsilon\sqrt{\delta}}{C_1^3C_2\sqrt{S}} = \frac{\epsilon}{C_1^3C_2}\sqrt{\frac{\delta}{S}} \qquad (6)$$

If we make $C_4 = C_2^3\,C_1^6$ we have

$$\delta = C_4S\left(\frac{W}{P_h\epsilon}\right) \text{ or,} \qquad (7)$$

$$C_4 = \frac{\delta}{S}\left(\frac{P_h\epsilon}{W}\right)^3$$

Values for C_4 for airplanes geometrically similar to the

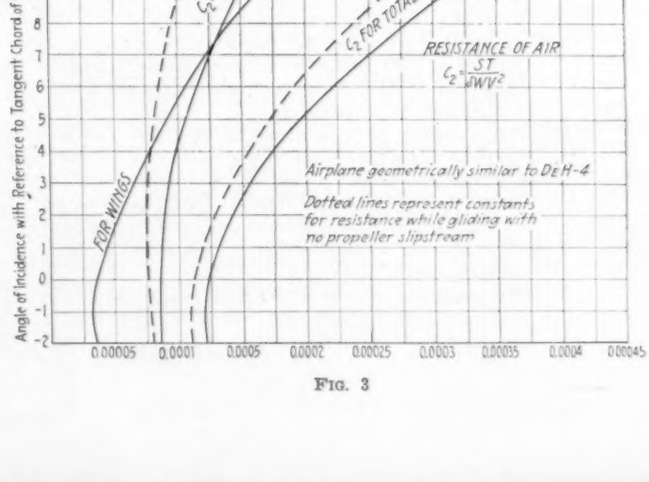


FIG. 3

DeHaviland-Four are shown on the curves in Fig. 5. The values of C_1 in these curves are not exact. For convenience in rapid, rough calculations, these have been corrected to care for the discrepancy in the value of W. When using Fig. 5 with equation (7), the value of W is the weight when leaving the ground and not the actual weight during flight tests. The consumption of fuel will, therefore, reduce W.

Gains from Maintaining Power at Great Altitudes

If an engine of the water-cooled type is used, with average modern-practice compression ratios and volumetric efficiency and having proper altitude carbureter control but no other device or means to maintain power at great altitudes, we can assume, to obtain *rough* results, that

$$P_h = P_o(\delta)^{\frac{1}{0.75}} \qquad (8)$$

No account has been taken in equation (8) of the variation with altitude of the percentage distribution of

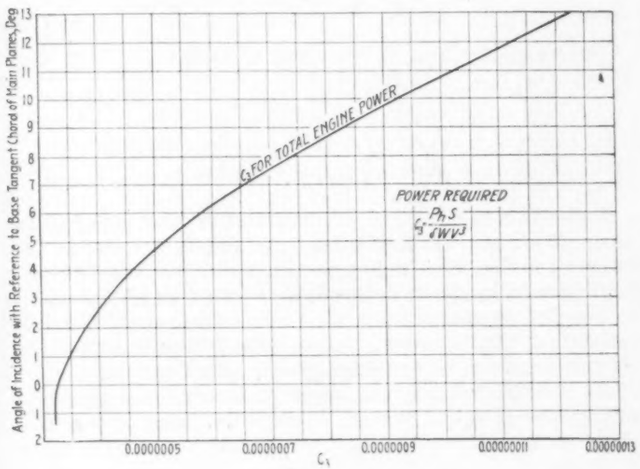


Fig. 4

the various gases in the atmosphere. In fact, about 20.8 per cent of the volume of the air at sea level is oxygen in the middle latitudes. This increases to 21.1 per cent at 30,000 ft. and decreases to 18.6 per cent at 60,000 ft.

Substituting in equation (7) the value of P_h as obtained from equation (8), we obtain

$$\delta = C_4 S \left(\frac{W}{P_o(\delta)^{\frac{1}{0.75}} e} \right)$$

Representing the fractional exponent of δ by the symbol Δ, we have

$$\delta^{(1+2\Delta)} = \frac{C_4 S W^2}{P_o^2 e^2} \qquad (9)$$

Working the other way

$$C_4 = \frac{P_o^2 e^2 \delta^{(1+2\Delta)}}{S W^2}$$

Fig. 7 gives a curve of δ plotted against $\delta^{(1+2\Delta)}$, so that the value of either is directly obtainable from the other. It also gives a curve of δ^{Δ}, for use with equation (8).

From equations (7) or (9) and equation (4), the approximate high speed can be obtained at any altitude desired, having given the values for power, weight and surface area, the method being as follows:

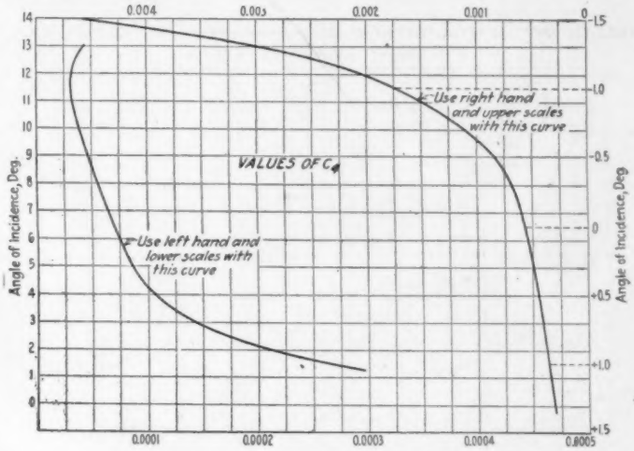


Fig. 5

First enter Fig. 1 and obtain the value of δ for the altitude desired. The only unknown quantity in equations (7) and (9) is then C_4. After obtaining the value of C_4, enter Fig. 5 and obtain the value for the angle of incidence. Then, from Fig. 2, for this angle of incidence, obtain the value of C_1. The high speed is then obtained by using equation (4).

With an airplane of a different geometrical and aerodynamical type from that of the DeHaviland-Four, having given P_h or P_o, S and *the horizontal high speed at any known altitude*, we can roughly predict its high speed at all altitudes, its ceiling, etc. The method is to substitute the known quantities V, S and δ, in equation (4), the value of δ being known from Fig. 1, and so obtain the value for C_1. Then, from Fig. 2, obtain the value of the angle of incidence. From Fig. 5 get the value of C_4 for this angle of incidence and substitute this in equation (7), obtaining a new hypothetical value for W, with which we then proceed, using C_1 and C_4 in equations (4), (7) and (9).

The stalling speed for any surface loading value and at any altitude can be obtained from the equation

$$V_s = C_{1s} \sqrt{\frac{S}{\delta}}$$

Values of C_{1s}, for various arrangements of planes with airfoils of sections R. A. F. No. 15, United States Army thick section No. 4 and United States Army No. 16, extreme cases, are shown in the table on page 6. It is assumed that the gap-chord ratio is between 0.95 and 1.10, and that in no case has any plane an opening in its center.

Comparison of Actual and Hypothetical Airplanes

Let us compare the speed of a present-day airplane with that of an hypothetical airplane in which is installed a means of maintaining its power constant at all working altitudes. Looking toward the future, it will be interesting to assume that the total airplane weight is the same in each case, 5000 lb. If the engine develops 500 hp. at sea level and the net area of the main planes is 556 sq. ft. in each case, then $S=9$.

In each case let us arbitrarily assume that under full throttle, the altitude and speed for horizontal flight are

VALUES OF $C_1 s$ FOR VARIOUS ARRANGEMENTS OF PLANES AND DIFFERENT AIRFOIL SECTIONS

Number of Planes	Airfoil Section	Aspect Ratio	Value of $C_1 s$
Monoplane	R.A.F. 15	5	17.8
		7	17.3
	U.S.A.-T.S. 4	5	14.4
		7	14.0
	U.S.A. 16	5	18.8
		7	18.3
Biplane	R.A.F. 15	5	18.6
		7	18.3
		9	18.1
	U.S.A.-T.S. 4	5	15.3
		7	15.0
		9	14.8
	U.S.A. 16	5	19.6
		7	19.3
		9	19.0
Triplane	R.A.F. 15	7	18.5
		9	18.2
	U.S.A.-T.S. 4	7	15.3
		9	15.0
	U.S.A. 16	7	19.4
		9	19.1

such that the angle of incidence required for sustentation is 2 deg.

The development of the variable-pitch propeller which, most fortunately, is contemporary with that of the supercharger, is leading in the desired direction, however. The supercharger would, relatively, be of little value without the variable-pitch propeller which, set at a very low pitch, permits climbing away from the ground, and, set at a very high pitch, should show good efficiency at very high airplane speeds, in air of very low density.

Case I. The engine power decreases with an increase in the altitude at normal present-day rate, with no novel means of maintaining it.

The following values are taken, or are already given:

$S = 9$ Angle of incidence = 2 deg.
$W = 5000$ lb. C_1, from Fig. 5 = 0.00021
$P_0 = 500$ hp.
$e = 80$ per cent

$$\delta^{(1+2\Delta)} = \frac{0.00021 \times 9 \times (5000)^2}{(500)^2 \times (0.80)^2} = 0.295$$

From Fig. 7 we obtain a value of 0.714 for $\delta^{(1+2\Delta)}$. From Fig. 1, the altitude corresponding to this is 10,900 ft. Substituting in equation (4) the value of C_1 for 2 deg. obtained from Fig. 2, which is 32.8, we obtain

$$V = 32.8\sqrt{\frac{9}{0.714}} = 116.5 \text{ m.p.h.}$$

Case II. Means are installed for maintaining the engine power constant with changes of altitude.

We will in this case assume a constant propeller efficiency of 0.80. From a practical standpoint, the maintenance of such an efficiency, constant at various speeds and in different densities, is today impossible.

We now assume that the total airplane weight in pounds divided by the horsepower developed by the engine at the altitude for a 2-deg. angle of incidence = 10. This is a very liberal assumption, and surely looks well into the future.

From equation (7)

$$\delta = C_s S\left(\frac{W}{P_h e}\right)^3$$

$$= 0.00021 \times 9\left(\frac{5000}{500 \times 0.8}\right)^3 = 0.296$$

This is an altitude of 35,400 ft. Referring to Fig. 1 for a value of C_1, we have

$$V = 32.8\sqrt{\frac{9}{0.296}} = 181 \text{ m.p.h.}$$

Case III. Suppose we fly at the same altitude in Case II as in Case I. Then, from equation (7),

$$C_1 = \left(\frac{P_h e}{W}\right)^3$$

$$= \frac{0.714}{9}\left(\frac{500 \times 0.8}{5000}\right)^2 = 0.00508$$

Reference to Fig. 5 will give a value of +0.22 deg. From Fig. 2, C_1=40.2, and

$$V = 40.2\sqrt{\frac{9}{0.714}} = 143 \text{ m.p.h.}$$

Following this method of computation and using equations (7) and (4) and Figs. 1, 2 and 5, we obtain the curves in Fig. 6, which presents a comparison between high speeds in the two previous cases at all altitudes.

Now let us obtain the approximate theoretical absolute ceiling of the machine of the second case, maintaining our assumption of constant power at all altitudes.

At absolute ceiling, the angle of incidence of this type of airplane is about 10 deg. This is the point of best lift-drag ratio. From Fig. 5, C_1=0.0000385, and from equation (7),

$$\delta = C_s S\left(\frac{W}{P_h e}\right)^3 = 0.541$$

Assuming that the density-altitude curve in Fig. 1 is approximately correct, the altitude is 66,000 ft. and

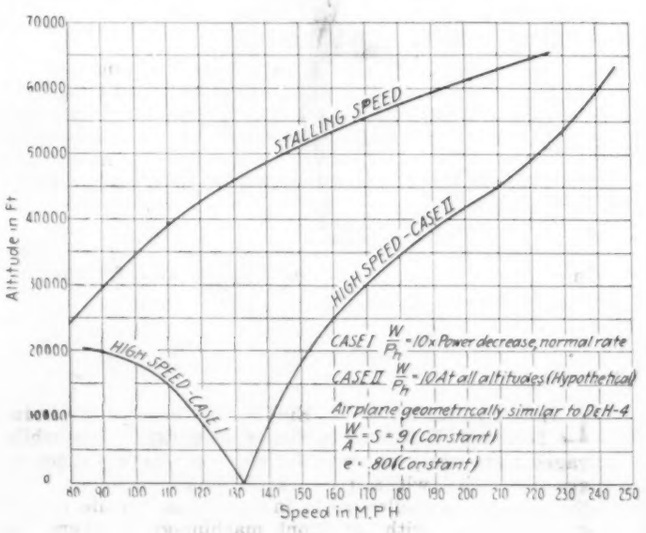

70000
60000
50000
40000
30000
20000
10000
0
Altitude in Ft
STALLING SPEED
HIGH SPEED - CASE II
HIGH SPEED - CASE I
CASE I $\frac{W}{P_h}$ = 10 x Power decrease, normal rate
CASE II $\frac{W}{P_h}$ = 10 At all altitudes (Hypothetical)
Airplane geometrically similar to DeH-4
$\frac{W}{A}$ = S = 9 (Constant)
e = .80 (Constant)
60 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250
Speed in M.P.H.

FIG. 6

$$V = 20 \times \sqrt{\frac{9}{0.541}} = 258 \text{ m.p.h.}$$

No suggestion will here be made as to the basic principle of the device or means for maintaining power with low density. Among the solutions suggested are a supercharging device at each cylinder to increase the compression and introduce more oxygen, a rotary air compressor driven by an exhaust gas turbine, or through gearing by a shaft, special fuels and the combination of the special fuel with a higher compression, etc. Designers must consider the extreme low temperatures encountered. Note the curve in Fig. 1.

Incidentally, the air compressor for the engine intake might also be used to maintain good pressure and introduce extra oxygen in a necessarily sealed compartment occupied by the personnel.

If engineers should go through a few numerical examples, following the method shown above, using the accompanying curves and noting results, they might become interested in development along this line.

In the general latitude of New York, Chicago and San Francisco, suppose that we could in certain seasons of the year, by rising to an altitude of about 40,000 ft., encounter a wind current having a velocity of 100 m.p.h., whose direction is such as to be "under the tail." If we could maintain a speed through the air of 200 m.p.h. at this altitude our speed over the ground would be 300 m.p.h. We could then, in flying time, go from Chicago to New York in 3 hr. and from San Francisco to New York in 9 hr.

Speed of travel or transportation makes for saving in time which, from the practical commercial standpoint, is tantamount to the elimination of space. Bringing San Francisco as near to New York as Pittsburgh now is by train, if it can be done, is a matter of tremendous importance. We should, therefore, look well into all means offering even the appearance of possible feasibility which may be suggested for helping toward this eventual accomplishment.

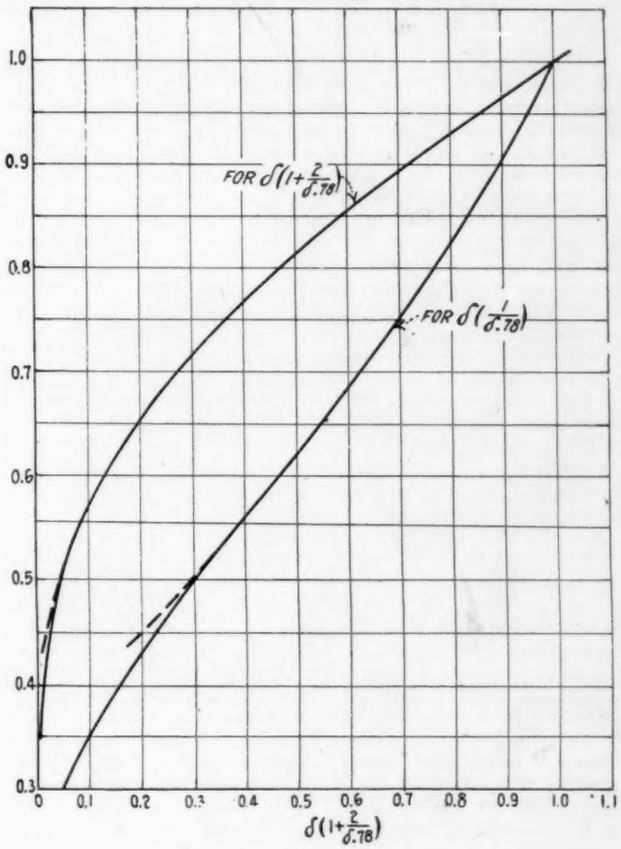


FIG. 7

THE CIVIL OPERATIONS BRANCH OF THE AIR SERVICE

MANY situations have arisen involving the activities of the Air Service, aside from its purely military value. These questions were taken up in detail and an effort made to satisfy the needs of the various civil departments. The result of the work accomplished can be seen from the report of the Department of Agriculture on forest fire patrol, carried on in Oregon and California by the Air Service in the fire season of 1919. The Air Service personnel, alone, discovered and reported 570 fires in California and Oregon. Plans have been formulated in cooperation with the Geological Survey to survey and map, by airplane, the unmapped portion of the United States. Plans have also been formulated in cooperation with the Coast and Geodetic Survey to survey the coast line of the United States and photograph the coast and adjacent waters.

In connection with the Bureau of Entomology, certain lands in Texas are protected by airplane patrols for the purpose of preventing the unlawful planting of cotton in what is known as the forbidden area. The cultivation of cotton in this belt has been made unlawful because of the attempt to segregate the boll weevil menace so prevalent in that section of Texas. The use of the airplane in this connection has been to detect the illicit cultivation of this product in this belt.

But by far the most far-reaching function of the civil operations branch is the inauguration and supervision of landing fields, known as municipal fields. On this is based the development of industrial and commercial aeronautics in the United States. There is on file in the landing fields branch complete information on over 1000 fields. Map routes have been projected, and a system of aerial route maps has been formulated. It is the function of this section to be in very close touch with the numerous civil activities, such as aviation clubs, societies and civic organizations for the promotion of the science of aeronautics.

SHOOTS AIRPLANE ENGINE LOOSE

LIEUT. McREYNOLDS, Eighth Aero Squadron, on duty at McAllen, Tex., had a remarkable experience while engaged in target practice. Machine guns have a synchronized gear attached which permits the pilot to shoot his guns through the propeller while in operation. While firing at a ground target with his front machine-guns several rounds entered the propeller, cutting off one end through faulty synchronization. He was forced to land immediately. Upon examination of the plane it was found that the engine had been torn loose from its bed, and the engine bed plates and supports were broken and twisted. How the lieutenant managed to get down without the engine falling out or either the plane suffering other damage or the pilot being injured is a mystery.—Air Service News Letter.

MOTOR TRUCKS AT FREIGHT TERMINALS[1]

A TEAM can successfully haul 75 ton-miles and a motor truck 500 ton-miles in a ten-hour working day. Compare this with railroad performance in which the average box-car movement is but 25 miles per day. If loaded with merchandise to but a 10-ton average, it discharges but 225 ton-miles in a twenty-four-hour day. It is therefore obvious that box cars suffer a handicap.

Freight-house operating practice demands that box cars lie idle ten hours a day. Utilized exclusively for transportation and kept continuously moving the remaining fourteen hours, even at an average speed of but 20 m.p.h. with 10-ton loads, the potential possibility of each freight car is 2800 ton-miles daily.

Refinements of present rail practice and additional facilities will occur, but rail transportation cannot be greatly improved because locomotives are now practically up to the safety limits of rails and bridges. Without increasing the weight of locomotives, drawbar efficiency cannot be increased and, without an increase in drawbar efficiency, transportation costs cannot be lowered. The field for improvement is thus, obviously, in terminals and terminal facilities.

The motor terminals installation at Cincinnati consists of overhead rails, electric cranes and hoists, motor trucks and a plurality of interchangeable motor-truck bodies. The system of operation requires an empty body for each station-movement demand of the railroad on its inbound main-station platform. At the larger stations there are several locations for such body settings, thereby decreasing the trucking distance for freight. As the freight comes from the cars it is trucked to the nearest location containing a body carded for any connection or any sub-station. When loaded these bodies are sealed and, under telephonic orders from a joint dispatcher employed by the railroads, they are mechanically loaded upon motor trucks and routed over the city streets to their designated connection.

Upon arrival at the outbound platform of the connecting line, the body is mechanically removed and an empty body, previously unloaded, is similarly put upon a motor-truck chassis for delivery to the inbound platform of that company. There the operation is repeated and another loaded body forwarded in the same manner to some other freight house.

If the load happens to be dispatched to a sub-station, it remains on the station platform until the dispatcher is advised by the sub-station agent that a return load is available. The loaded body of inbound freight to that sub-station is then forwarded, and the motor truck exchanges this load for the previously mentioned load of outbound freight to be delivered at the main station. There it is consolidated with other city freight in line cars made up daily for innumerable other destination points.

All freight, except possibly the portion arriving in the last hour of the station operating day, whether between main and sub-stations or between main stations of the various railroads, is currently loaded and sent out of the terminal. Previously, this freight by trap cars suffered an average of three days' delay, and the shuttle movement of these individual cars over terminal rails interfered with the group movement of complete cuts of station cars which previously made Cincinnati notorious as a check-valve in rail routing.

The flexible possibilities of trucks are now clearly defined for industries whose transportation facilities are dependent upon rail extensions. Opportunities at each point are limited only to intelligent installations following detailed analyses to establish the greatest terminal deficiencies of the carrier to meet the shipping demands of the public.

[1]Extracts from a paper presented at the convention of the Material Handling Machinery Manufacturers' Association, New York City, Feb. 26, 1920, by B. F. Fitch. The author is president of the Motor Terminals Co., New York City.

RECONSTRUCTION IN FRANCE

IN the territory of the Château-Thierry salient there is hardly a house untouched by shell fire and there is hardly a field untouched by the plough. The people have come back. They are living in cellars or small wooden barracks, the most temporary of emergency quarters answer the purpose, and every hour is given to the land. Houses and barns will come in future years. They must wait until the land has done its best.

Shell holes and trenches are filled; barbed wire by the ton is rolled up. Across the fields, as far as the eye can reach, may be seen the lines of big French horses or yokes of four or six oxen steadily plodding along. Every member of the family is able to help. Guiding the team, the plough or the harrow is within the capacity of old and young alike.

These people are pioneers once more, but in quite a different way from the American pioneers. They come back to a country with perfect roads, well-established boundaries, the railroad, telegraph, telephone, motor truck and many other facilities. Their lot is not that of the American pioneer. It is the comparison with what they have lost that hurts. Houses, capital, much of their live stock have gone. All the heirlooms handed down from past generations have been destroyed. The present generation starts again to build for the future. These people are infinitely better off than the peasants on this land of 100 or even 50 years ago. It will not take long to build up from the soil a civilization equal to or better than that which has been wrecked by the German invasion. That they are going to do it, there can be no doubt.

In the cities the problem is quite different. Rheims had a population of 120,000 before the war. Now it is estimated that 60,000 people find lodging and a living in the ruins. Practically not a house or building is untouched by shell fire. A very large number are destroyed. Exposure to the weather for three or four years has added to the damage. Temporary boarding has made some houses and hotels habitable. Around the station are many wooden barracks. Electric lights are again intermittently available. Gangs of men are stringing wire for the dilapidated street railway not yet in operation.

Sightseers are everywhere and the souvenir venders are doing a thriving trade. The cathedral in its majestic ruin is photographed hundreds of times a day. But there is not a true beginning for the rehabilitation of a splendid prosperous city, and the future is not as clear as is that of the farmer on his own land. All the complicated details of industry must be built up. Labor, capital, machinery, markets for product, housing must slowly fit together to make a city over again. Patching and a tourist trade are not enough.

Soissons is more wrecked than Rheims. Fismes, still worse, is a souvenir of good American artillery practice, as a French officer expressed it. These cities and many others in the war area all the way to the Channel make the complete revival of France a work of many years and much saving.

This is the cold gray dawn of the morning after. The excitement is over; the music of war has died away. There must be many a headache, as well as heartache, among these plodding, struggling men and women, who labor from dawn to dark. There is little of joy in the present, and yet they are steadily at work among the crosses on which hang the blue helmets in honorable memory of men who saved this land for those who have come back to build again.—Eliot Wadsworth in *The Evening Post* (New York).

NIGHT SIDE GUIDE & GRIPPER

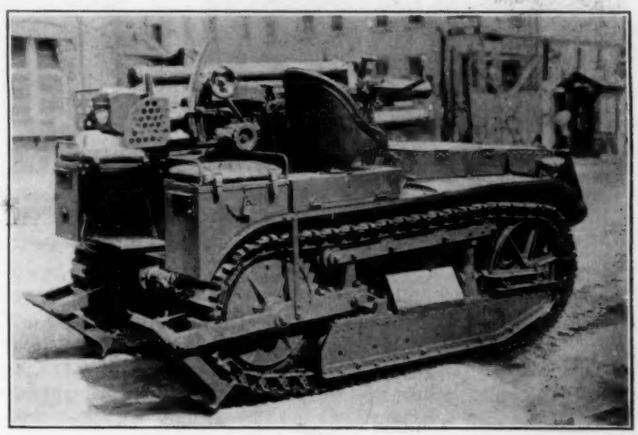
Successfully Submerging a Gasoline Engine

By Capt. Levin H. Campbell, Jr.[1] *(Non-Member)* *Illustrated with* Photographs

ONE of the objections advanced by all informed officers in regard to the motorization of artillery is the fact that it is not possible for a tractor or a self-propelled gun-mount to ford streams which can be forded by horse-drawn vehicles. The effect of water entering the carbureter or short-circuiting the ignition system is the factor which limits the capability of tractors or self-propelled gun-mounts to ford streams. Of course, if the carbureter and the ignition system be raised, the depth of water through which the tractor can pass is increased by the amount these elements are elevated. For some time the design of a watertight engine has been considered and, so far as is known, no serious obstacles have been met.

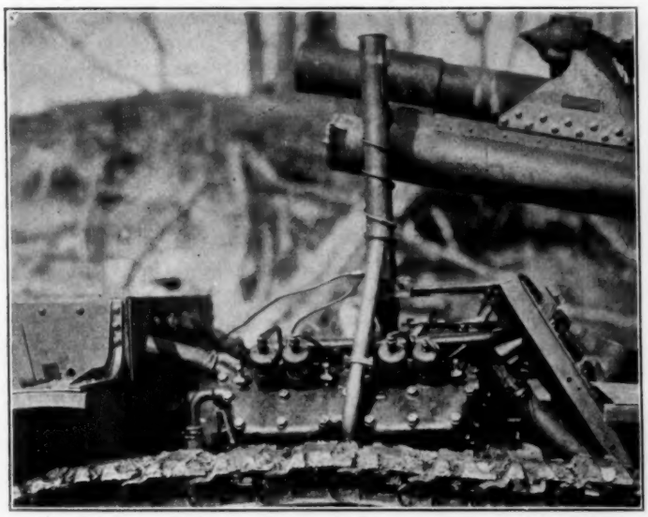
To test the feasibility of running an engine under load submerged in water, the artillery division of the Ordnance Department initiated steps to have the engine in the self-propelled caterpillar mount, Mark VII, for the 75-mm. gun, Model 1916, waterproofed. It should, of course, be understood that the waterproofing of this engine is entirely an improvisation as the engine used is the standard Cadillac eight-cylinder engine, such as is found in passenger cars bearing that name.

The success of this experiment is largely due to the efforts of Capt. L. A. Miller, of the Ordnance Department, and E. W. Barnhart, of the Holt Mfg. Co., who are both stationed at the Aberdeen Proving Ground, Maryland. No claim for originality, either in the conception of the idea of waterproofing the engine or in the mechanical execution of the problem, is made; but, so far as known, this is the first instance in the history of the gasoline engine of an engine running under load completely submerged. Especial note should be made of the fact that the tractor was run a distance of about 3 miles, so that the engine and its exhaust manifolds were thoroughly heated. The tractor was then immediately run into water which was below the freezing temperature of 32 deg. fahr. In fact, this water was so cold that the gasoline in the carbureter was frozen. In spite of the heated condition of the engine, the exhaust

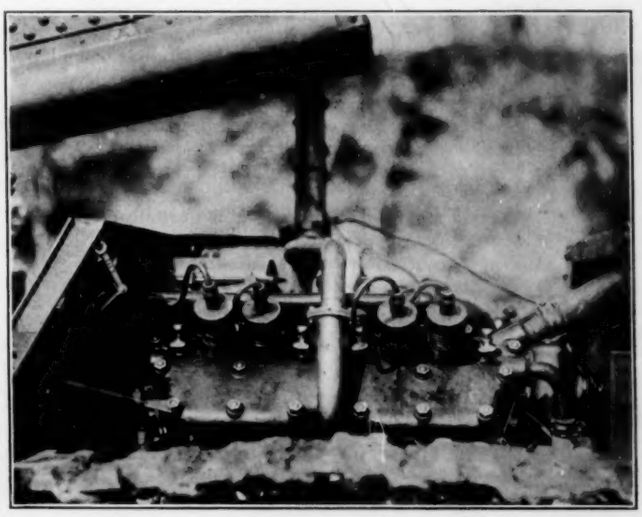


Self-Propelled Caterpillar Mount Mark VII for 75-Mm. Gun

[1]Chief of caterpillar mount section, artillery division, Ordnance Department, Aberdeen Proving Ground, Maryland.

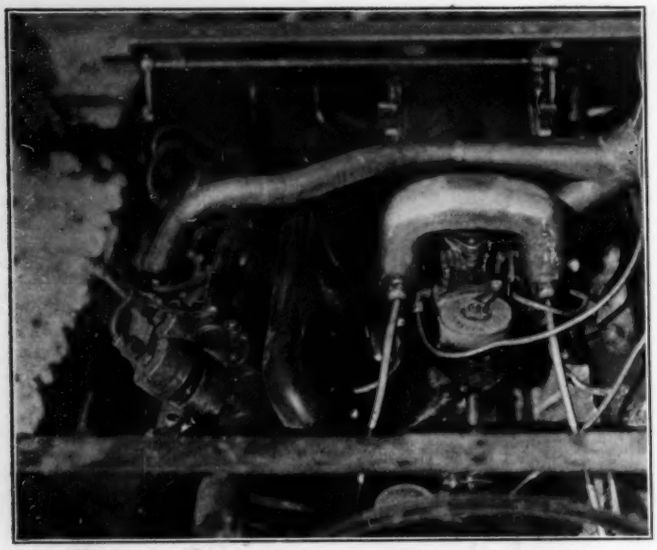


View of Left Side of Engine



View of Right Side of Engine

In Both Views the Waterproof Box for the Magneto, the Waterproof Covering for the Spark-Plugs, the Waterproof Electric Cable, the Copper Pipes Leading from the Crankcase Breathers to the Stand-Pipe and the Copper Tubes for the Carbureter Auxiliary Air and the Intake of the Gasoline Pressure Pump Are Shown



A View Taken from the Front of the Engine

The Carbureter, the Copper Pipe Leading from the Air Intake of the Carbureter to the Stand-Pipe, the Copper Tubes Leading from the Auxiliary Intake of the Carbureter to the Stand-Pipe and from the Stand-Pipe to the Gasoline Pressure Pump and the Watertight Box Covering the Magneto Are Shown

manifolds and other hot parts were not injured in any way.

It thus appears that the depth of water through which a tractor or self-propelled gun-mount can pass, is limited only by the height to which we bring the stand-pipe for the air intake to the carbureter.

The object of this test was to determine the convenience and action of firing of the Mark VII, caterpillar mount, and also its ability to travel on and off the road, noting its speed and stability, particularly the obstacles and difficult places over which the tractor can safely pass. On or about Dec. 1, 1919, instructions were received from the Ordnance Office to place mount No. 2 in running condition and to attempt to develop a waterproof engine, so that the mount might run when the engine was entirely submerged.

To waterproof the Cadillac engine it was necessary to

(1) Waterproof the spark plugs and provide waterproof electric cables
(2) Waterproof the magneto and distributor and provide waterproof electric cables
(3) Waterproof the carbureter and provide auxiliary air-pipe for the carbureter and an air-pipe for the intake of the carbureter
(4) Provide an air intake for the gasoline pressure pump
(5) Waterproof the crankcase and provide air-pipe for the crankcase breathers
(6) Waterproof the exhaust
(7) Waterproof the valve hand-hole plates
(8) Waterproof the clutch case

Details of Waterproofing

The materials used in waterproofing each spark-plug were two 1½-in. pipe caps, a 1½ x 2-in. nipple, and a copper-lined asbestos gasket. The body of the spark-plug was turned down in a lathe and threaded so that a 1½-in. pipe cap which had been drilled and tapped would screw over it. A copper-lined asbestos gasket was placed between the shoulder of the spark-plug and the cap. The gasket was placed over the plug and the plug was screwed tightly into the cap. The nipple was next screwed into the cap. The top cap was next drilled and tapped for a ⅜-in. packing nut of a waterproof connection, the packing nut being screwed tightly into the cap. The gland was next slipped over the electric cable and the cable was passed through the packing nut of the cap and attached to the spark-plug. The top cap was then screwed tightly onto the nipple. White lead was used on all threads. The gland was packed with lampwicking and white lead and screwed tightly into the packing nut.

The magneto was covered with a specially designed watertight copper box. A packing-gland was provided for the magneto drive-shaft and small brass packing-glands were provided for the cables which lead to the distributor. This watertight copper box was attached to the aluminum magneto bracket by cap screws, a rubber gasket being placed between the bracket and the box. A cover was made for the box which was clamped down on a rubber gasket by four wing-nuts.

A French carbureter was used for this test instead of the Cadillac carbureter. A copper air-pipe was run from the air intake of the carbureter to a large vertical copper stand-pipe, which was designed to stand about 2 ft. above the water level when the engine was submerged. A small copper tube was run from the auxiliary air intake of the carbureter and attached to the stand-pipe. A cap and a gasket were provided for the float-plunger.

One of the bearings of the butterfly-valve shaft was sealed with brass, while the other bearing was provided with a gasket and a washer, the washer being held against the gasket by the control lever.

The air intake provided for the gasoline pressure pump was a small copper tube, similar to the one used for the auxiliary air of the carbureter, and was run from the air intake of the gasoline pressure pump and attached to the stand-pipe.

All joints of the crankcase were provided with rubber gaskets, shellac being placed on one side of the gasket and white lead on the other. One and one-fourth-inch copper pipes were run from the crankcase breathers to the main stand-pipe. All joints were provided with watertight gaskets.

For the exhaust two 2-in. check-valves were placed in the exhaust pipes about 4 ft. from the engine, and between the engine and mufflers, which were removed for this test. It was necessary to employ check-valves in case the engine should stop while submerged.

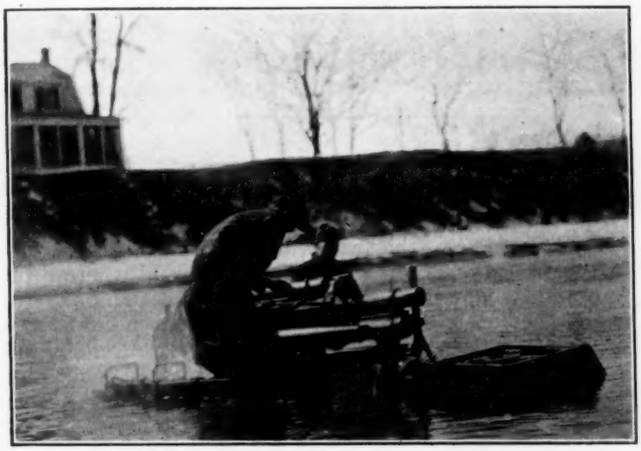
For the valve hand-hole plates rubber gaskets were placed between the valve hand-hole plates on the engine and the engine casting.

For the clutch case rubber gaskets were placed on each end of the main clutch shaft. These gaskets were held in place on one end by a cotter key and washer and on the other by a washer and the operating lever.

The Submersion Tests

All repairs on the tractor were completed about Feb. 25, 1920. The waterproofing of the engine was completed about March 1. The detachable engine armor was removed and a piece of paulin substituted therefor. On the morning of March 2, the mount proceeded to Woodpecker Point under its own power, and descended to the edge of the Chesapeake Bay. Here the paulin was removed and the watertight cap was placed over the float-plunger. The radiator fan was thrown out of gear and the mount was made ready to proceed into the water.

The mount left the shore and proceeded slowly into the water. The slope was gradual and the water rose slowly until the mount was about 100 yd. from shore.



THE ENGINE RUNNING WHEN ABOUT THREE-FOURTHS SUBMERGED

Here the engine was completely submerged, the depth of the water being about 4½ ft. The mount was stopped in this position and the engine was allowed to idle for about 5 min. The gears were then reversed and the mount returned to the shore, showing no ill effects. Here the engine was allowed to idle for about 15 min., when it was stopped.

After about ¾ hr. the engine was started and the mount made a second trip into the water. The mount ran out about the same distance as before and the engine was again completely submerged. The mount was stopped and the engine was allowed to idle for a few moments. The gears were then reversed and the mount started for the shore. The mount started back rather suddenly and some water was splashed up by the footboard and entered the stand-pipe. This caused the engine to stop.

A 10-ton artillery tractor was sent into the water a short distance and a line was thrown to the mount from the tractor. A cable was pulled out and attached to the mount. The other end was attached to the 10-ton tractor, which then started to tow the mount ashore. The clutch of the mount was thrown in and after being towed backward about 10 ft. the engine of the Mark VII started, while still about three-quarters submerged. The cable was removed and the Mark VII proceeded ashore under its own power. The engine was submerged about 30 min. during this test. The temperature of the water was about 32 deg. fahr. Cakes of ice were floating in the water and solid ice was about 200 yd. from shore.

On the morning of March 3 the Mark VII mount again proceeded to Woodpecker Point and again entered the bay as on the day before. The mount went out about the same distance from the shore, when the engine was completely submerged. It was allowed to idle for a few moments in this position, when it backed ashore as before. During this test the temperature of the water was about 32 deg. fahr. and cakes of ice were floating in the water. Solid ice was about 200 yd. from shore. In the afternoon this test was repeated. After the engine was submerged it was allowed to idle about 20 min. The condition in the water was the same as before; temperature of water about 32 deg. fahr. and cakes of ice floating around. Solid ice was about 200 yd. from shore. At the end of the 20 min. the engine stopped. The mount was immediately towed ashore by a 10-ton artillery tractor. Upon inspection it was found that the carbureter had frozen, stopping the gasoline supply for the engine. The carbureter was allowed to thaw out, which took about 20 min. After the carbureter had thawed out the engine started readily.

The mount entered the water again and proceeded to a point where the engine was completely submerged. The engine was allowed to idle for about 10 min., when it stopped. The mount was towed ashore by a 10-ton artillery tractor and upon investigation it was found that the packing-gland of the magneto drive-shaft, in the copper box covering the magneto, had become loose, which allowed water to enter the magneto box, which short-circuited the magneto.

This concluded the test and the mount was returned to the shop for repair, the report of the proof officer being that the Cadillac engine had been successfully waterproofed so that the mount can ford streams which completely submerge the engine.

AMERICAN MOTOR CARS IN AUSTRALASIA

A MARKED increase in the popularity of the type of motor-car design represented by American practice in the past year is reported by a trade investigator for a large builder of passenger cars who has just returned from Australasia. He states that American cars have a high reputation in Australia and New Zealand and that while there will always be some demand for British cars, this country will continue to dominate the market. In August, 1919, 598 passenger cars valued at $664,442 and 44 motor trucks valued at $64,481 were exported from the United States to Australasia. These figures could have been increased if production and the overwhelming demand in this country had permitted, and the same condition is true at present.

There has been an embargo on the importation of complete cars although one body to every two chassis has been permitted entry. All parts of such bodies and all accessories are taxed at various rates ranging from 10 to 50 per cent of their value. The body-making industry has sprung up in Australia, although the manufacture of complete cars has not been encouraged.

The cost of motoring in Australasia is much higher than in this country. The initial price of a car is twice that in the United States, due to packing charges, freight rates and import duties. The prices of oil and gasoline are also high, being approximately $2.40 and 60 cents per gal. respectively, or approximately double the corresponding prices in this country.

High-Speed Indicators

By THOMAS MIDGLEY, JR.[1] (*Member*)

ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS AND DRAWINGS

AN indicator is an instrument for getting a graphical representation of the pressures within an engine cylinder, which are plotted against some other function of the engine such as the piston position or the crank angle. The original indicator was invented

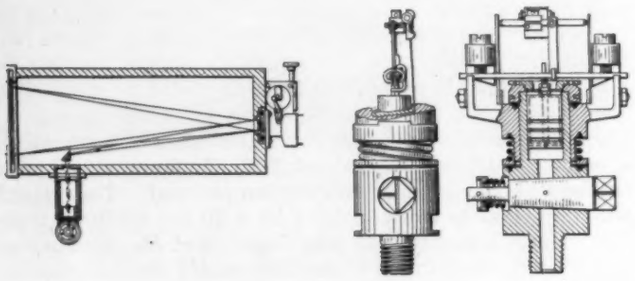


FIG. 1

by James Watt and used by him in his great engineering work on the steam engine. In the early development of the internal-combustion engine the indicator played an important part as long as the speeds encountered were low, but with the rapid advance of the art to high-speed engines the instruments were unable to reproduce records at these higher speeds reliably because of the inertia effects of the moving parts of the pressure element.

Improvements upon indicators became necessary, and while it is interesting to note these developments they have without exception fallen short of the mark for exact-pressure studies. But there have been a few research laboratories where the indicator has been employed almost constantly in showing the variations of pressures; as in the development of valve-timings to serve a given speed range; the development of combustion-chamber form; the location of spark-plug electrodes; fuel studies, etc. In these applications it is unnecessary to know the values of

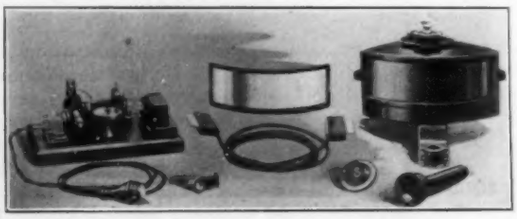


FIG. 2

the pressures but merely their general relationships; and the indicator so used becomes a purely qualitative instrument.

That there is a need for an instrument of great precision can scarcely be questioned, and that such an instrument will fill a field of broad usefulness can readily be proved by the results already obtained. But whatever our need for an ultra indicator of pressure values and its broad usefulness, the fact remains that for general use, where speed of observation is essential and where a picture of a single pressure cycle or an indication of the variations among successive cycles without necessarily a record of it is required, the highly developed and simple qualitative optical instrument will have wide application.

It is hoped that the foregoing has served in some measure to make clear the need for two classes of indicating instruments; first, a purely qualitative one of the so-called optical type with which a complete and instantaneous mental picture of the pressure events of the cycle is secured; and, second, a purely quantitative type of instrument, with which an exact record of pressures can be obtained. The common requirements in both types are (*a*) that the timing of the indicator shall correctly follow the positions of the crank and (*b*) that the pressure recorded shall agree with the pressures developed within the combustion space.

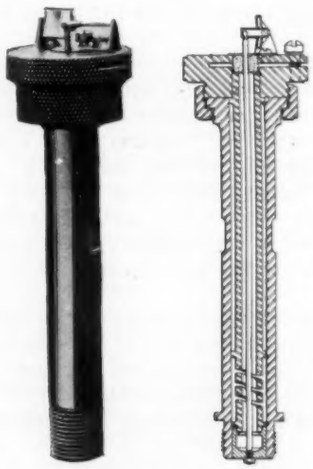


FIG. 3

In any discussion of the foregoing requirements, the first is most easily satisfied. The nature of the motion-transmitting mechanism will depend, in the optical type, upon the kind of diagram sought; i.e., whether the pressure is plotted against the piston positions, called the pressure-volume diagram, or against the crank angle, called the pressure-time diagram. To secure the former, which is that from which the mean effective pressure is determined, it is necessary to oscillate the indicator mechanism in synchronism with the piston of the engine. This involves a reproduction in the indicator mechanism of the engine crank-rod ratio, and also of the crank offset, if any. This drive involves joints and bearings which must be free from back-lash. All these parts are avoided in the drive for making pressure-time diagrams, a simple, continuous rotary motion being all that is necessary. In the optical type for fuel studies, the pressure-time form of diagram is superior, since the pressure events are expressed directly in terms of the crank angle; and the interesting phenomena at the ends of the strokes are not

[1]Mechanical engineer, research division, Dayton Metal Products Co., Dayton, Ohio.

hidden through crowding, as in the pressure-volume diagram. This will be observed from some of the studies shown. In the polar pressure-time diagram the atmospheric line is a circle and the pressure ordinates are radii of the circle.

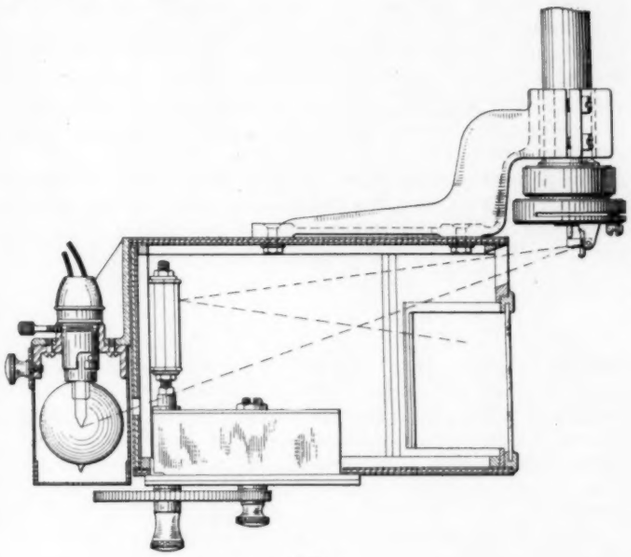


FIG. 4

The second requirement, perfect agreement between recorded and actual pressures, is only satisfied with a negligible length of passage between the cylinder and the pressure-deflected portion of the indicator; and in indicator work at high engine speeds the only passage having a negligible length is one having none at all. This limits us to the use of a spring-controlled piston in the pressure

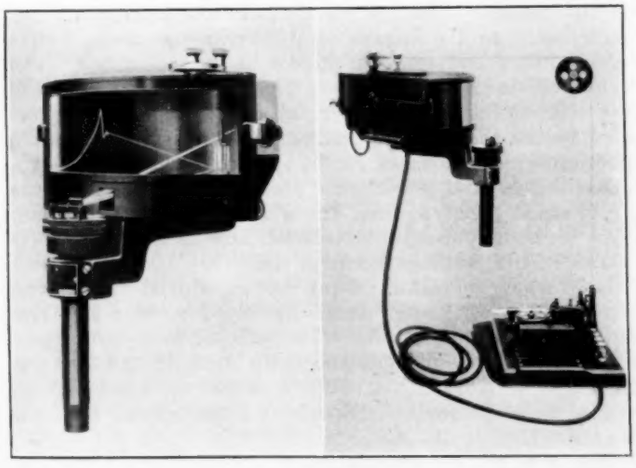


FIG. 5

element, since the popular diaphragm of the conventional optical indicator cannot be subjected to the temperatures of the combustion-chamber gases, inasmuch as it must serve as its own spring. In the case of the ultra indicator hereinafter described, the diaphragm is not a spring, and hence can be and is exposed to the hot gases. The elimination of vibration troubles in the pressure element is most difficult of solution and is only satisfied through very careful design.

We will now demonstrate two instruments. One of these represents a high degree of perfection of the relative type for optical study combined with a degree of accuracy which is well within the accepted limits of engineering. The other indicator, developed at the National Bureau of Standards, is, we believe, the highest development of the second class, possessing accuracy to a most remarkable degree. It is unfortunate that the only principle so far advanced that permits of practical embodiment in an instrument of extreme accuracy is one which cannot be combined with the desirability of optical observation. This latter indicator is to a large extent the child of adversity, as its development was necessary to make any such studies whatsoever in the altitude chamber. For this reason it deserves special credit as a most remarkable piece of research work.

In the conventional type of steam-engine indicator, typical of those used in the early days and still used on large installations of stationary engines where the speeds are slow, a piston is exposed to the cylinder pressures

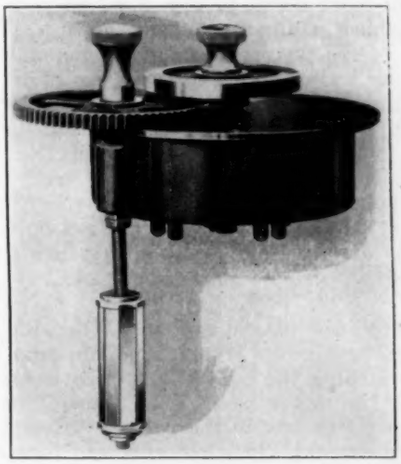


FIG. 6

through a connecting pipe which also serves to keep the gases cool, and its deflection is resisted by a calibrated spring. This motion is transmitted through a series of levers and is recorded by a pencil on a paper fastened to the drum which in turn is oscillated by a string connection to some portion of the engine.

The instrument known as the manograph (Fig. 1) represents the next type of advance. A diaphragm is made

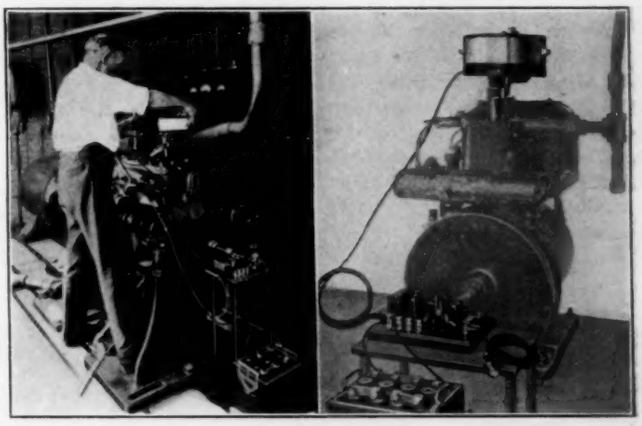


FIG. 7

use of in the pressure element; but the big contribution made to the art by this instrument is the beam of light which is used to replace the moving arms of the preceding type. I have already mentioned the disadvantages of the diaphragm. It cannot be subjected to heat and retain its spring qualities. Another serious disadvantage is its irregular calibration, which gives trouble if the instrument is used in any other than a purely qualitative way.

As an improvement upon the manograph, Prof. Hopkinson devised the instrument shown at the right of Fig. 1. This is a reversion to the piston-type instrument but, because of the type of spring used, the calibration is still far from perfect. This development failed to make use of one of the greatest assets of the piston-type pressure elements, that is the ability to get right down on the wall of the cylinder-head and thus eliminate all connecting pipes and chambers. The parts of one of these instruments are shown in Fig. 2. This instrument is shown in more detail in Fig. 3 which is a cut of the pressure element of the instrument shown in Fig. 2. The element is of the piston type and is compactly arranged in a unit, one end of which screws directly into the combustion chamber. Pressure in the cylinder operates against the piston to compress the resisting spring. This movement is transmitted through a very light shaft to an arm which operates to change the vertical angle of a mirror supported on a horizontal axis in proportion to the pressure on the piston. A cross-section of the box, showing the arrangement of lamp, pressure element, revolving mirror, ground-glass front, etc., is shown in Fig. 4.

Fig. 5 shows the optical system. When the system is in operation, light issues from a small aperture in a metal casing surrounding the light bulb, which is supported on the back of the motor box. This beam of light passes through the motor box to the concave mirror on top of the pressure element. It is reflected and focussed by the pressure-element mirror, and again traverses the length of the motor box to the eight-sided mirror in the rear, which can be either oscillated or revolved, according to whether pressure-volume or pressure-time cards are desired. The convergent rays of light from the pressure-element mirror, after being reflected by the eight-sided mirror, are projected forward upon the curved glass forming the front of the motor box. This point of light moves up and down with a corresponding change in the angle of the pressure mirror. At the same time it moves horizontally with the oscillation or rotation of the octagonal mirror, thus tracing out on the curved glass either pressure-volume or pressure-time cards. Fig. 5 is also representative of the arrangement which gives pressure-volume cards. Included in the crankshaft attachment is a member driven by a crank attached to the distributor head and having a reciprocating motion in a vertical direction. A fine wire is attached to this member and carried over a light pulley to an arm which transforms the reciprocating motion into an oscillation of the eight-sided mirror about its vertical axis.

The synchronizer, shown in Fig. 6, is used in taking pressure-time cards. Its function is to rotate the eight-sided mirror located within the motor box, so that its speed can always bear the same definite ratio to the speed

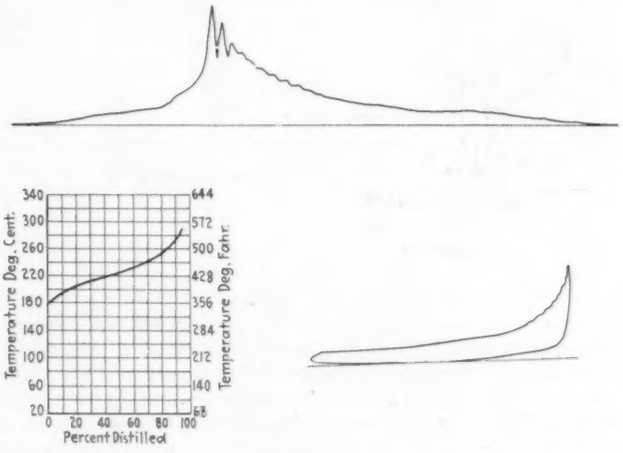


FIG. 9

of the engine. The system comprises a mechanism for attachment to the engine or dynamometer shaft, and a synchronizer and rotating mirror in the motor box. The synchronism is accomplished electrically by energizing the coils of the synchronizer through a distributor operated by the shaft of the crankshaft attachment. To take photographic records of cards, it is only necessary to replace the ground glass with a clear glass, hold a piece of bromide paper against the glass and press a button. The bromide paper is developed and a single card is found. This result is accomplished very simply by electrical means, merely a timing device which subjects the lamp to two or three times its rated voltage for two revolutions of the engine. The time of two revolutions is too short to burn out the lamp until it has given a thousand or more cards. Fig. 7 shows the indicator installed in a dynamometer room and the operator taking a card.

Fig. 8 is the representation of a study which this indicator has made possible. This is a fuel study of gasoline upon a Delco-Light engine which was purposely put out of adjustment to study the knocking tendencies of various fuels. Notice upon the pressure-time card, following from left to right, the rise on compression, the point at which ignition takes place; then the smooth rise along the combustion line, passing the dead-center at about the maximum pressure; then the almost immediate drop of pressure, due to the downward movement of the piston and the expansion of the gas; and finally, the opening of the exhaust valve. Again, from left to right, the results of the exhaust stroke are traced by a second beam of light. Notice now the drop of pressure as the intake

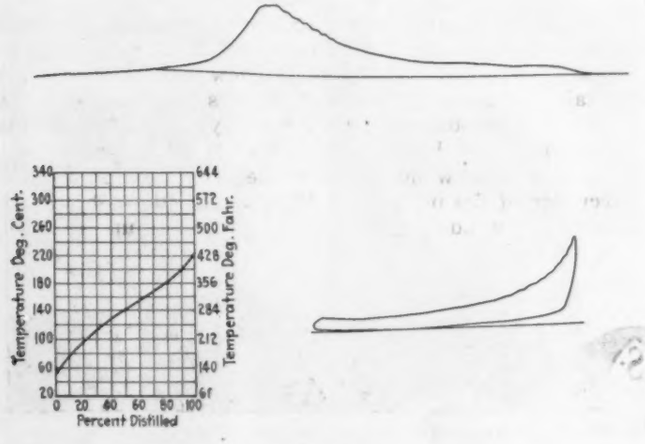


FIG. 8

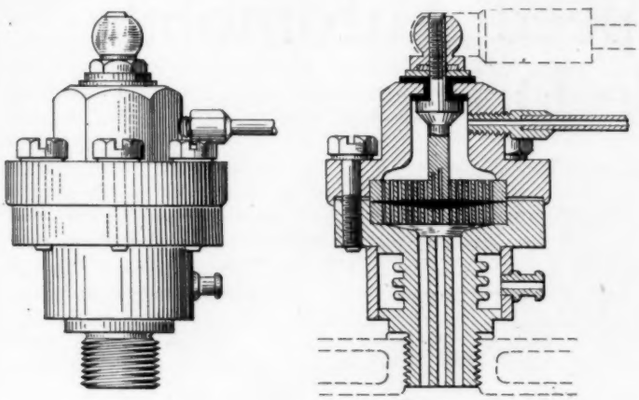


FIG. 10

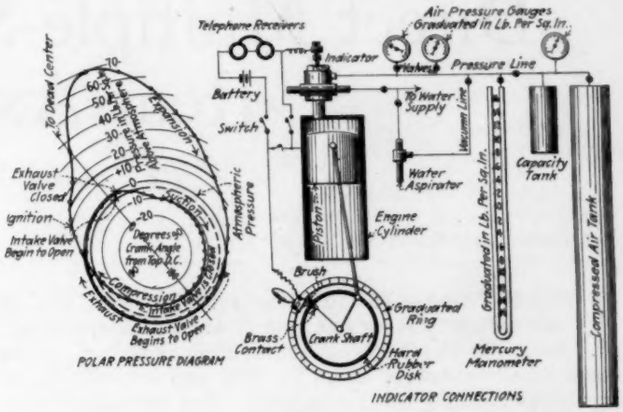


FIG. 11

stroke commences. And, passing to the right of the card. the same cycle would be repeated. This card is typical of a gasoline from a paraffin-base crude. Notice that the pressure-volume card shows but few of the characteristics of the fuel. The distillation curve of the gasoline is shown.

In Fig. 9 is shown a study of a sample of kerosene made on the same engine and refined from the same crude oil as was the gasoline. This engine was purposely put out of adjustment to study knocking of the fuel. The spark is intentionally early; the carbureter was purposely formed within the cylinder-head. Notice now the differences between this pressure-time card and the previous one; while the pressure-volume card remains practically the same. Notice the rise on compression as before and that the rising is in a perfectly normal manner. But here something happens that does not occur in the previous case. Some sudden rise of pressure takes place and this exerts itself as a sharp "pink," which is called preignition or knocking.

The development at the Bureau of Standards of indicators for high-speed internal-combustion engines has included a diaphragm indicator of the balanced-pressure type that has proved thoroughly successful. It (See Fig. 10) consists of a steel diaphragm about ¾ in. in diameter and 0.002 in. thick, clamped in a small chamber and subjected on one side to the varying cylinder pressure and on the other to a constant pressure of any desired and measurable value, supplied by a compressed-air tank system or a vacuum system. An electric contact point is located above the diaphragm and is in circuit with a telephone or spark-coil indicator when this controllable pressure just balances the engine pressure at any desired phase in the engine cycle. The diaphragm chamber screws directly into a hole in the engine cylinder-head, an extra spark-plug hole, eliminating uncertainties due to long connecting pipes and leaving the clearance volume unchanged. The only moving part is the 0.002-in. thick diaphragm, which moves but a few thousandths of an inch, will respond to instantaneous pressure without error, and is practically unaffected by vibration. The record obtained is an average from the same phase of many consecutive cycles, although a point or click is observed for each cycle.

The commutating segment in serier with the telephone (See Fig. 11) makes contact once per engine revolution. If at the time of this contact the diaphragm be in the upper position against the electrode, the electric circuit is complete and the telephone clicks. On the other hand, if the diaphragm be down, the telephone will remain silent. The diaphragm will be up or down according to whether the pressure at the instant is greater or less than the steady pressure exerted on the top from the air-pressure tank, measurable by gage. As an example, suppose the gage reading to be 20 lb. per sq. in., 35 lb. absolute. Then the telephone will click whenever the engine pressure is more than 20 lb. per sq. in. above atmospheric pressure, at the crank angle of commutator contact, and will remain silent if the pressure be less than that value. The method of operating is therefore to set the commutator as desired and, while listening to the telephone clicks, gradually increase the gage pressure applied to the top of the diaphragm until the telephone clicks cease, recording this critical gage pressure.

The exact determination of the above point is possible only with exact repetition of pressure values every cycle in the engine. With the usual variations from cycle to cycle, what the observer hears as the critical value approaches is an intermittent clicking, say two, three or a half-dozen clicks, then perhaps half a second's silence, then a few more clicks, then another pause, etc. Some judgment must, therefore, be exercised in choosing the condition to select as representative of average pressure at the phase under measurement.

A specimen indicator card from pressure measurements every 10 deg. in the cycle of a Waukesha truck engine is reproduced in Fig. 11 to show what results can be obtained. Although these first runs were made at low speeds, later observations on both cylinder and manifold pressures have been made at speeds up to nearly 3000 r.p.m., and show no effect of speed on the operation or accuracy of the indicator. More recent curves have been made on cylinder and manifold pressures up to speeds of 2400 r.p.m.

Direct Multiple-Speed Automobile Rear-Axle Drives

By H. C. McBrair[1] (*Member*)

Metropolitan Section Paper *Illustrated with* Drawings and Photographs

I BELIEVE that the first car equipped with two or more direct drives and sold to any considerable extent was the Sizaire-Naudin, first exhibited at the Paris Small Inventors' Show in 1905 and actually placed upon the market a few years later. The transmission of this car (See Fig. 1) is located on the rear axle and consists of a single large crown gear mounted on the differential, just as the larger gear is usually mounted in the ordinary bevel-gear-drive axle. Three pinions of different diameter are provided to mesh with this crown gear for three forward speeds, in addition to the reverse idler. This gives direct drive on all three forward speeds, but it is effected at the expense of an abnormally large diameter of crown gear, which has teeth of a curved form giving point contact only with the pinions and a complicated motion of the pinion shaft in two directions for gear-changing.

A transmission embodying similar principles of gearing, worked out in a different manner, was brought out

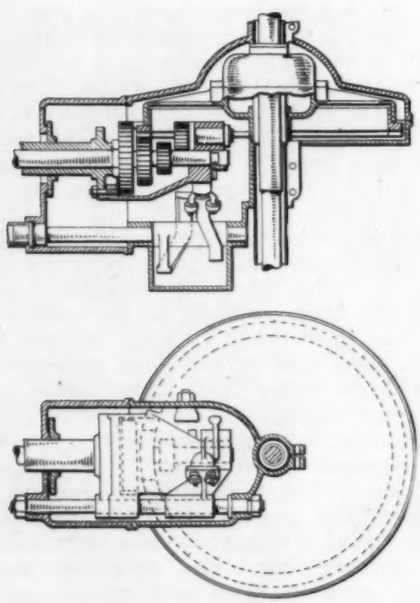


Fig. 1

in 1909 by the Seagrave Co., Columbus, Ohio, but I am not aware that it ever met with any commercial success. In this device, which was called the Probst or Stone-Probst axle (See Fig. 2) there were only two direct drives, the low and reverse gears being geared down so that the size of crown gear required was not so great for the same power capacity; and a single pinion was used, sliding along its shaft without motion in any other direction, to obtain the several changes of gear ratio.

[1]Middletown, N. Y.

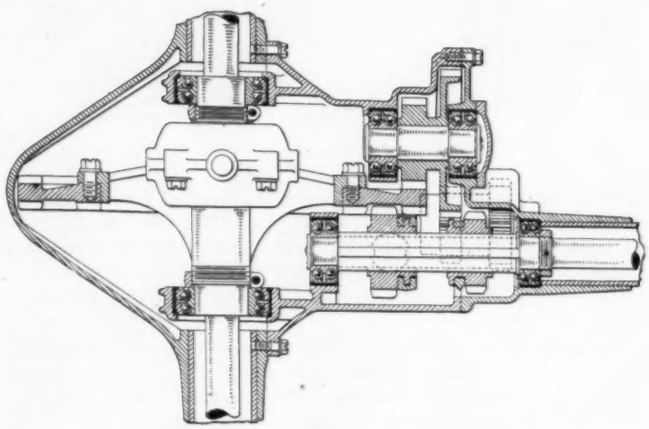


Fig. 2

This was accomplished by cutting two sets of crown teeth on the same face of the axle gear, with space between the two circles for a neutral position of the pinion. These two crown gears gave direct drive on the two higher speeds. A third set of crown teeth was cut on the back of the same blank, into which a countershaft pinion constantly meshed. A gear for first speed also was on this shaft and was engaged by shifting the sliding pinion forward from its neutral position, which was just in front of the rim of the crown gear. An idler was slid into mesh with a countershaft gear and the sliding pinion to obtain the reverse.

Early American and Foreign Forms

After the Sizaire-Naudin the next real double direct-drive transmission to be exploited was the Pleukharp transmission axle, made in 1906 by the Direct Drive Axle Co., Columbus, Ohio. The principle of this gear is shown in Fig. 3. There are two bevel pinions and three bevel gears, all being mounted loosely on their shafts. There are also two double-jaw clutches and a roller-coaster clutch of the type which has now come into use in connection with engine starters. The diagram shows the low-gear position, the drive being through the roller clutch. The reverse is obtained by shifting the clutch on the axle so as to engage the other large gear, the clutch on the propeller-shaft being still in the rear position, where it

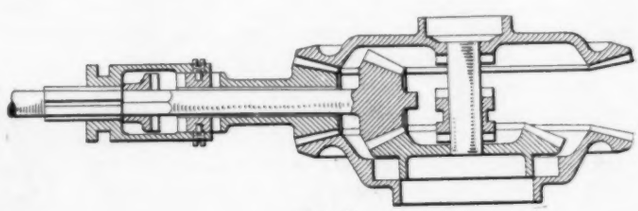


Fig. 3

engages the forward pinion. For high gear, both clutches are shifted from reverse position and the roller clutch allows all the gears which are not in use to stand idle. Only two forward speeds are provided, the clutch on the propeller-shaft selecting between them, while the clutch on the axle is not disturbed except when the reverse is brought into action.

What may be considered the real ancestor of the present double-drive rear axles is the Pilain transmission (See Fig. 4), which was exhibited at the Automobile Club of America show in New York City in December, 1906, although this is not truly a double direct-drive, as a second gear reduction is provided by spur gears at the rear-wheel hubs. The way in which the two bevel pinions were engaged was not revealed by the makers at that time, but probably there was something in the way of a pair of internal spur-gear clutches inside the small housing on the primary gear-shaft.

Designs similar to the Pilain have been used in gear-boxes made integrally with jackshafts for double-chain

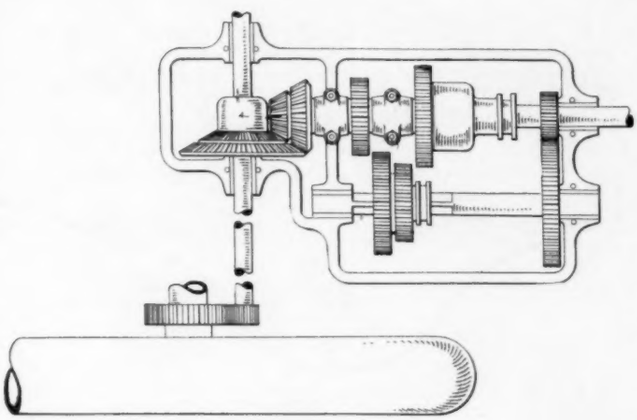


FIG. 4

drives in a number of makes of car, notably the Italian Lancia, shown in Fig. 5, and the French Berliet, Fig. 6, made familiar by its production in this country by the American Locomotive Co. for several years before it brought out the Alco car; and in a truck transmission, Fig. 7, designed and exhibited by the Merchant & Evans Co., Philadelphia. The last named firm designed also a similar rear-axle-mounted gearset, which was not to my knowledge built and sold, although the truck transmission has been sold in some quantity.

A form of transmission which was first used in the Mors car some ten years ago, has two pairs of bevel gears, one for the direct drive and the other for the countershaft. While this gives direct drive on only one gear, it reduces the number of gears through which the power is transmitted on the lower gears. This type of transmission was made familiar in this country on chain-driven cars by its use on the Knox, Matheson and Chadwick cars. The American designs favored placing the bevel gears back-to-back, bringing the countershaft to the other side of the transmission, and one of these gears at least was of the selective type.

I believe that the Austin Automobile Co., Grand Rapids, Mich., was the first to use a two-speed axle of the simplest and lightest possible form to give two direct drives in connection with a separate gearset to give additional forward speeds and the reverse. The smaller bevel pinion

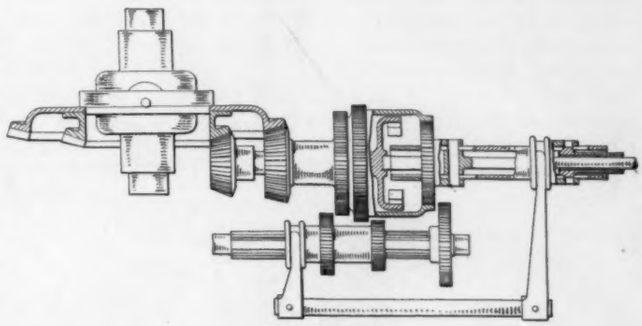


FIG. 5

and the larger gear are fast on the propeller-shaft and differential respectively, the mating gear and pinion being clutched. The two jaw clutches required are interconnected so as to operate like one double clutch, while the construction is simpler and more substantial than that of any of the double clutches used in preceding constructions of this sort.

This axle gives two independent direct drives and in conjunction with a three-speed gearbox, six properly graded speeds. The chief advantage, of course, is the double direct-drive. The construction is very clearly shown in Fig. 8. There are two bevel pinions and two bevel gears, the pinions being concentric and mounted one closely behind the other, and the gears are the same. The larger bevel pinion and the smaller bevel gear are loose upon their shafts, but can be secured thereon by dog clutches. The shifting collars of these clutches are interconnected so that when one is in engagement the other one is free. The largest pair of gears gives the smallest gear ratio. So far the Austin company has made three different sets of these gears, giving gear reductions of 3½ to 1 and 2 to 1; 4 to 1 and 2½ to 1; 4½ to 1 and 3 to 1. This Austin design overcomes certain of the difficulties by the use of one clutch on a pinion and the other on a gear, at the same time gaining a very compact construction. As the outer gear is solid on the

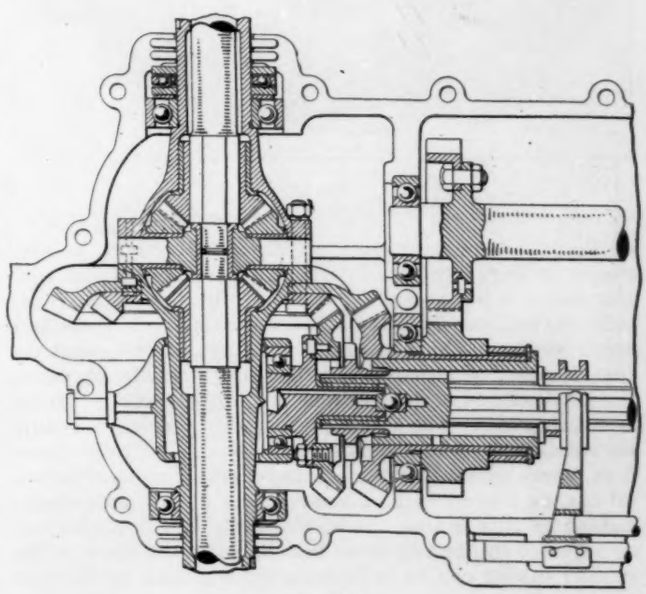


FIG. 6

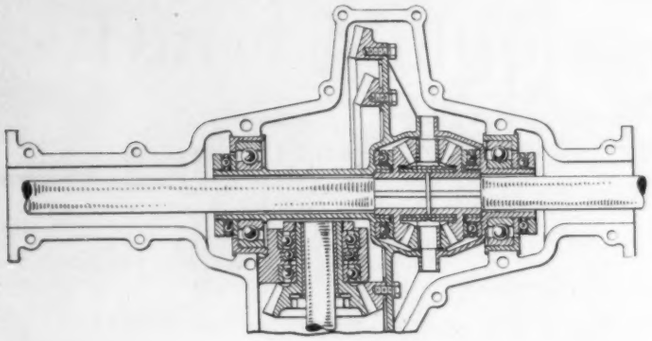


FIG. 7

differential, the inner one is just as well backed-up when clutched as though it were solid also.

For further suggestions of double bevel construction a drawing of the bevel gears of the Berliet design is shown in Fig. 6. This was used in the gearbox of the Alco car as long as a double-chain drive was used on that car. Here we find the shifter sleeve passing through the bore of one of the bevel pinions, the jaw clutch being between the pinions themselves.

MODERN TWO-SPEED AXLES

Fig. 9 shows that in the bevel pinion and jaw-clutch assembly of the Cadillac design every force has been considered, and there is no uncertainty as to sufficient support such as we observe in the Pleukharp design. Yet we apparently see a few leaves out of the Pleukharp book in the separate support of the outer sleeve with its bevel pinion. The universal-joint is attached to a solid shaft which goes through to a bearing back of the bevel pinions

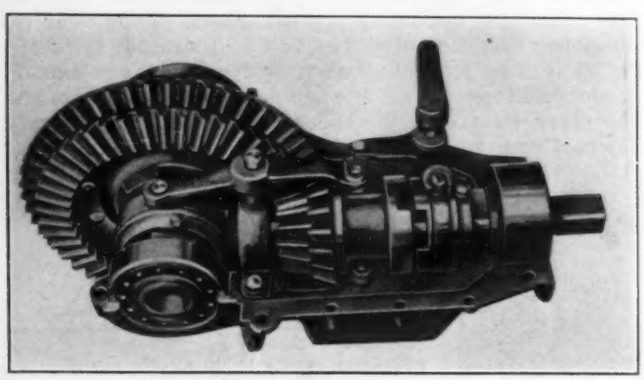


FIG. 8

as though there were but one pinion. However, neither pinion is keyed to this shaft. The smaller pinion with the sleeve is supported on the shaft by two small roller bearings and located by ball thrust-bearings. If these look small as compared with other bearings in the construction, it must be remembered that they are idle whenever the small pinion is driving and turn only when the pinion is running idle. The larger pinion, with its sleeve, is supported directly from the housing by two taper roller bearings, there being clearance between the two sleeves and no chance for contact or wear. One of the advantages gained by this is that the mesh of the larger pinion can be adjusted by the two outer bearings and the mesh of the smaller pinion can be independently adjusted by the two

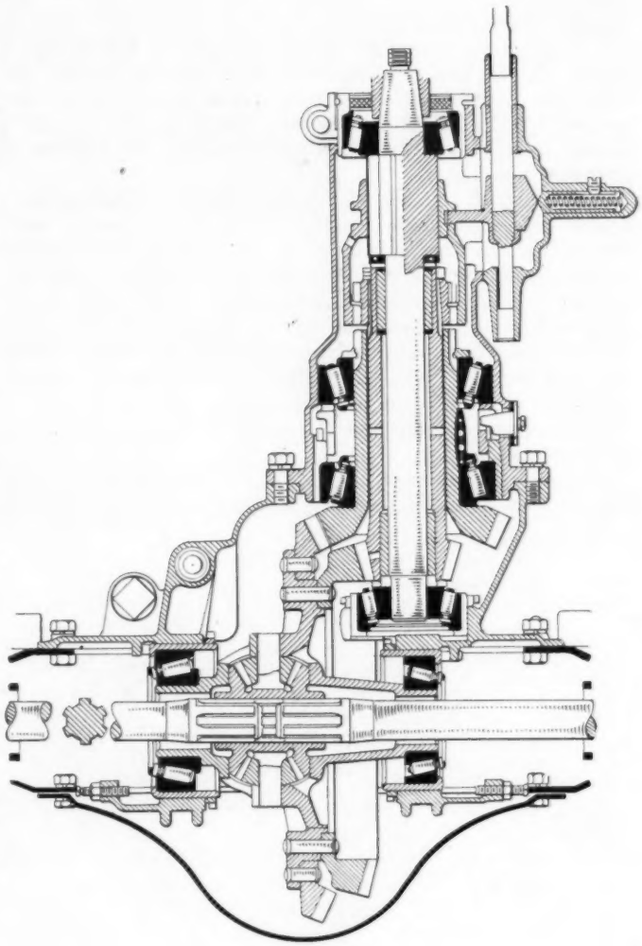


FIG. 9

bearings which support the shaft. The forward end of each of these sleeves carries a spur gear which is used as a clutch, connection being made with the propeller-shaft through the internal gear, which is shown in neutral position between the two spur gears. The internal gear slides upon an enlarged and splined portion of the through-shaft, being operated by a shifter. A spring lock retains the shifter in position for clutching either gear,

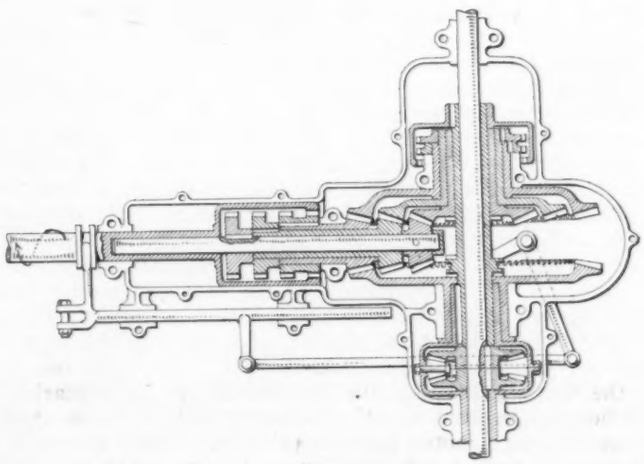


FIG. 10

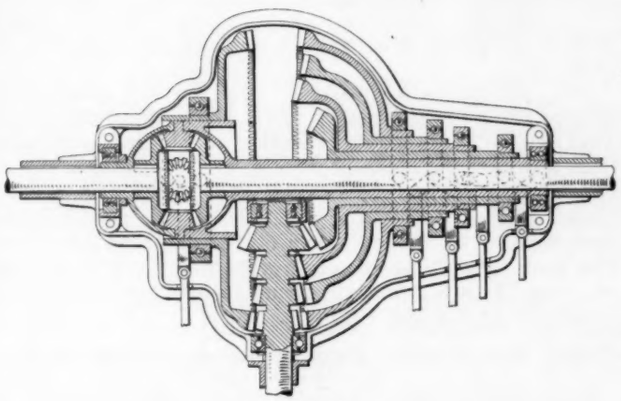


FIG. 11

but the neutral position, in which the clutch is here shown for the sake of clearness, is not used. The two large bevel gears are solidly attached to the differential, and the sizes are such as to give a ratio of 3.66 to 1 with the smaller pair, and 2½ to 1 with the larger pair.

As the bevel-gear ratios of the Cadillac are 2.50 to 1 and 3.66 to 1, while the second gear-reduction in the transmission is 2.18 to 1 they give gear reductions as follows for the four highest gear ratios: 2.50 to 1, 3.66 to 1, 5.41 to 1 and 7.98 to 1. These are in almost exact geometrical ratio, the multiplier being 1.47, which is the ratio between the two direct drives; as 8 to 1 is low enough for everything except emergencies and extreme grades, it is necessary to have a lower gear for only such

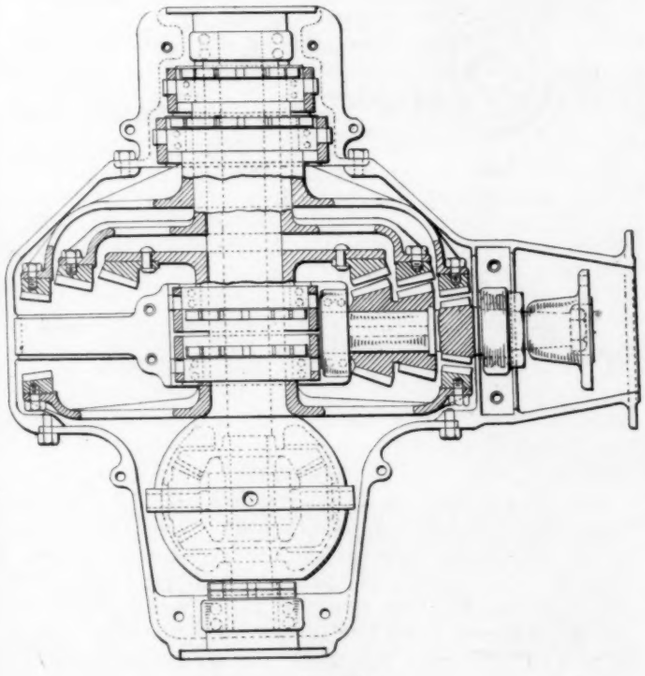


FIG. 12

conditions. The same multiplier used again gives a low-gear ratio of 11¾ to 1, which is near the actual ratio of the lowest gear obtainable, making five gears in nearly geometrical ratio from 11¾ to 1 to 2½ to 1. The arrangement as adopted has the practical advantage that the car can be started on either of the rear-axle drives, using the regular transmission gear-reductions as though there was no double direct-drive. This would still be true if the low gear in the transmission were in geometrical relation to the other gears in the transmission, but this would give a uselessly low gear of 17.3 to 1. On the other hand, it would bring the two direct drives too closely together, and make it necessary to resort to an indirect drive more often if the multiplier in the geometric ratio

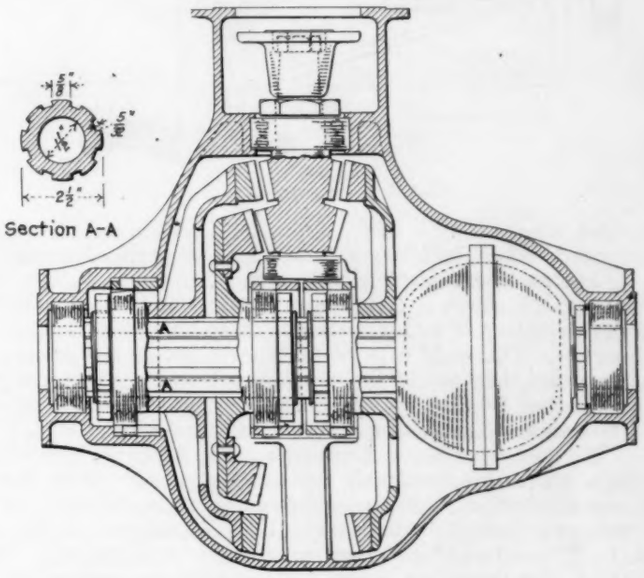


FIG. 13

were reduced to 1.35 so as to give six speeds in geometrical progression from 2.5 to 1 to 11.6 to 1. It would be hard to improve upon the ratios that have been adopted. The Muren axle, Fig. 10, has three speeds forward and a reverse. In this axle dog clutches are used on both pinion gears and bevels. The use of hollow pinion-shafts limits the gear reduction and places the high gear on the

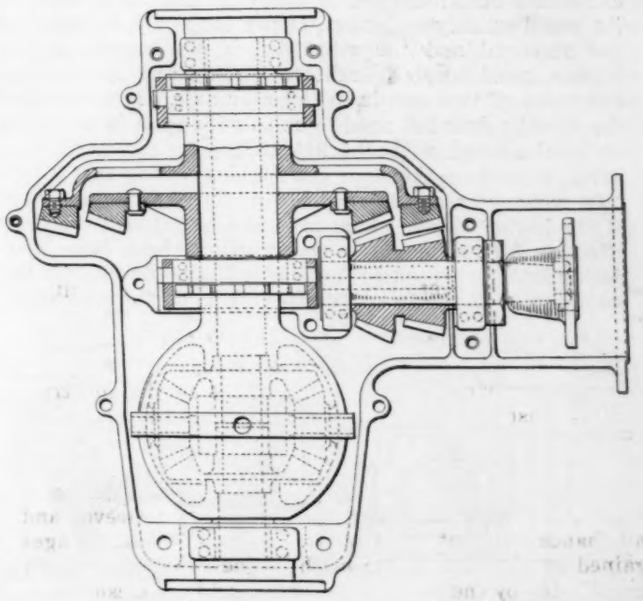


FIG. 14

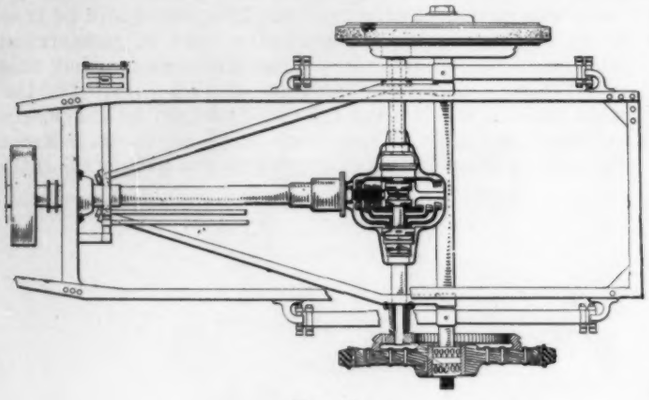


FIG. 15

large bevel. The idling of gears without proper bearings is another bad feature of this axle.

Fig. 11 shows a four-speed forward and one reverse device with a 2 to 1 ratio on high and a 9½ to 1 ratio on low. This axle with 36-in. wheels gave more ground clearance than one of the popular makes of car of today; more than 9 in. clearance. The objection to the axle was its weight; it also had a poor shifting device.

We now come to practical axles. The first one, Fig. 12, is a light two-speed axle weighing not more than the average ordinary axle in common use. The clearance on this axle is 10½ in. with 34-in. tires. Quoting J. G. Perrin, "The effect of unsprung weight is a broad subject. I think that there is a happy medium between sprung and unsprung weight; if we go to either extreme we lose in the best riding qualities of the car." J. N. Heald says, "I have been driving lately a car with a two-speed axle having ratios of 2½ to 1 and 3 2/3 to 1. I use the 2½ to 1 ratio very much; and yet in driving an hour I will change perhaps ten times from one speed to another. It is interesting to show the difference between the engine running first on one bevel gear and then on the other. At a speed of 25 m.p.h., for example, a change from the 2½ to 1 gear to the low bevel will tend to retard the car unless additional gas is given the engine to increase its speed quickly by about 50 per cent. The additional gas required and the vibration of the engine at the higher speed seem to indicate quickly and conclusively the value of two speeds in the rear axle. It seems that the throttle does not need to be as wide open in traveling on level ground with the 2½ to 1 gear as on the low bevel, to produce the same car speed, showing that a certain amount of gas is required to turn the engine over at the higher speed, which produces no actual propelling effect as far as the car is concerned. I have been wondering lately whether a six-cylinder engine developing the same power as the four-cylinder in this car in connection with a two-speed rear axle, would not prove to be the ideal car."

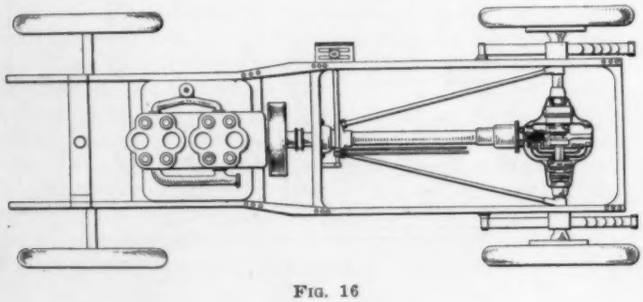


FIG. 16

Fig. 13 shows a two-speed and reverse axle; with splined differential housing upon which the gears slide. This axle will give ample reduction on low gear and more than 9-in. ground clearance. Fig. 14 illustrates a three-speed forward and reverse axle; Fig. 15 the axle as connected to the chassis, and Fig. 16 the axle used in connection with an internal-gear drive for truck purposes. The gear ratios that are easily obtainable with this axle are from 2 to 5 for high, from 3 to 6 for second and from 6 to 12 for low.

The Relation of Gear Ratio to Horsepower

J. G. Vincent has said: "An indirect gear ratio below the direct, that is higher than 60 per cent of the direct, will give very little added ability. If it is as much as 70 per cent of the direct, it will not give any. I will put it another way. Take a hill of certain grade that a given car will just climb on the high and maintain 20 m.p.h. Make the gear ratio 60 per cent and the car will be able to accelerate." Quoting from E. T. Birdsall, "That bears out some experience I had with a foreign car. It had three speeds. The second speed was 66 per cent of the third. On a given grade it would not pick up, whereas with cars that I made with the second speed 60 per cent of the direct there was no trouble in accelerating. I found practically the same thing that Mr. Vincent found, that 60 per cent of the high gear is about as high as one can go to advantage."

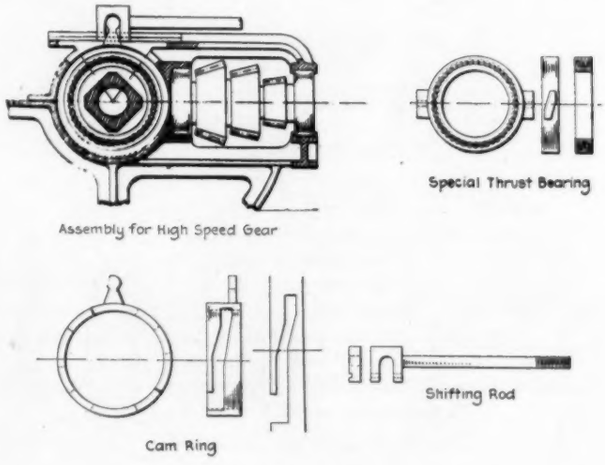


FIG. 17

The gear spiders shown in Fig. 17 slide on a splined differential housing, being moved into position and locked by rotating a cam ring against the lugs on the ball bearing. The ball bearing is fastened to the gear spiders in the usual manner; the cam ring has a recessed bearing so that it cannot move horizontally. As the cam ring is rotated to put a gear into mesh, the lug passes along the inclined plane until the flat surface is reached and the gear becomes locked in position; when the lug is at the center point the gear is in neutral. When one gear, the high gear, for instance, is in mesh and the lug is at the flat-surface end of the inclined plane, the cam ring on the second-speed gear has passed from the center point to the long flat surface and has become locked out of mesh at that point. The gears are coupled up in the usual manner. It is possible to have a three-speed forward and

reverse drive, using a light two-speed axle for high and intermediate speeds and a light gear-box for low and reverse. This can be made so as to use only one lever.

The low-speed ratio drives are through spiral bevel gears. A low-speed pinion with nine teeth would give excellent results, since it would probably not be used for more than 2 per cent of the total mileage.

Figs. 18 and 19 show gear assemblies, Fig. 20 a special ball bearing and Fig. 21 a carrier bearing.

The Discussion

J. A. Anglada:—We hear of proposed five and six-speed trucks, with reference particularly to trucks equipped with pneumatic tires. Why are not more two and three-speed rear axles used?

Dr. McBrair:—One reason advanced is greater weight, but the two-speed axle is as light as the average standard axle made today.

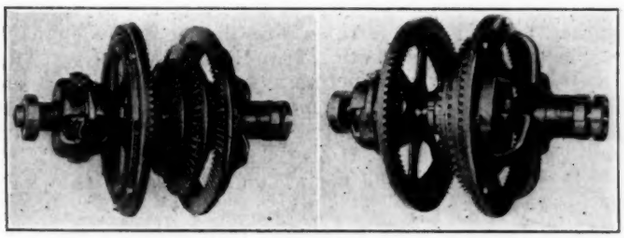


Fig. 18

Fig. 19

P. M. Heldt:—The gear efficiency is one necessary consideration. With a double direct-drive the gearset is not used so much. Gear efficiency is not a definite thing but varies with the speed and the load. A well-cut pair of spur or bevel gears will show 98 per cent efficiency if operated at moderate speed and with a fair load, but the efficiency will decrease as the load decreases. A gear running free requires some power to drive it and does no effective work; hence the efficiency is zero. If no more power is taken out of it than that required to drive it free, the efficiency cannot be more than 50 per cent.

A. L. Clayden:—I do not remember who was responsible for the first multiple-speed axle. It was produced long ago. I remember such a car, but it was not the Pilain. Another French car with a three-speed axle was produced about 1903, and Renault had at least a two-speed rear axle about 1904 or 1905.

Another form of multiple direct-drive was experimented with in England about 1900. Its pinions consisted of two disks spaced an adequate distance apart and connected by pins parallel to the axles. I believe it showed a high efficiency.

The reason the multiple-speed axle has not been used to a greater extent lies not so much in its weight, because we have realized only in recent years that an ounce in the rear axle is worth about 50 lb. above the spring, as far as easy running is concerned, but is due to the extreme difficulty of shifting gears with accuracy and without interference with that operation due to road shocks. The Cadillac magnetic method of operation was developed to overcome the extreme difficulty of arranging a mechanical shift. I do not mean to suggest that it is impossible to arrange a straight mechanical control, but it is not easy. Many engineers prefer to have someone else work it out for them.

H. W. Slauson:—I rode in Dr. McBrair's car six or seven years ago. It was really a revelation in control

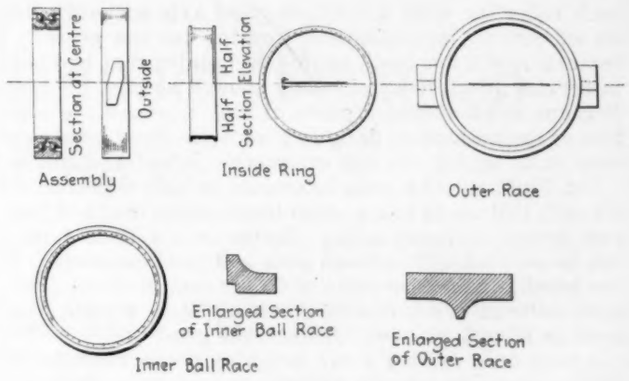


Fig. 20

and general ease of handling. The various speeds, second or third if necessary, could be obtained with the same feeling as though driving on direct all the time.

It is said that the two-speed rear-axle Cadillac was an ideal car to drive for those who understood just how and when to operate it.

Mr. Clayden:—I have recently driven an Austin rear axle and the shifting is very good. I think that it is no easier to drive than an ordinary transmission, and it requires no more intelligence.

H. C. Gibson:—With the McBrair type of axle there is less churning of the oil than with the other types of multiple-speed rear axles. It may happen that he can use light oil, in which case there would be a great increase of efficiency. What is the actual means of shifting?

Dr. McBrair:—The first experiments were made using grease in the rear axle, but in cold weather the bearings did not receive proper lubrication. We afterward found that engine oil gave the best results.

In regard to gearshifting, it is possible to shift from high to second, or from second to high speed while running along at 25 to 30, 10 to 15, or 50 to 60 m.p.h. The gear can be shifted at least eighty times per minute if the hand lever can be pulled that fast and I think it can. It is possible while running at 25 m.p.h. to kick the clutch out and throw the reverse gear in so that, when the car stops and the clutch is let back in, the car will go backward. It is impossible to "grind" the gears in any way, or to get any noise when shifting from one gear to the other. The gears are as quiet as any in high-gear drive.

Mr. Anglada:—On the average car there are low-gear reductions of 12 to 16 and 18 to 1. Is it possible to obtain

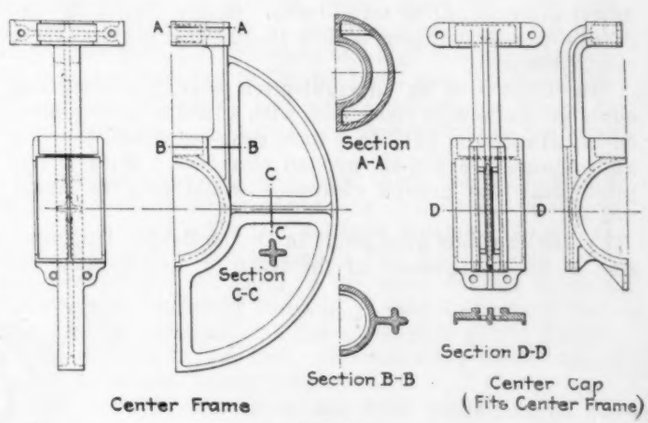


Fig. 21

such reduction with a multiple-speed axle without using an excessively large-diameter housing for the gears? I recently saw a five-tooth spiral-bevel pinion that had been in service about 7000 miles and showed no sign of wear. Perhaps small-diameter gears of this type are the solution of the problem of designing multiple-speed bevel-gear rear axles which are not excessively large in diameter.

DR. MCBRAIR:—A man interested in axle manufacture recently told me he had a seven-tooth pinion that had been run several thousand miles. Better than a 12 to 1 ratio can be secured with a small gear and good clearance. If the benefit of the gear ratio of 60 per cent of direct drive, with indirect drive, can be obtained, 12 to 1 ratio is as good as 15 to 1, or more, through the gearbox.

I have been driving a car weighing about 3500 lb., including equipment, and it has always come through. Once, coming over the mountains through deep snow, I had the radiator leaking from bucking snowdrifts. So, I think the gear reduction is a small part of it. We started with a gear ratio of 12 to 1 on low. We have gradually gone down until we have 7½ to 1 for low, 4 1/5 to 1 for second and 2¼ to 1 for high speed.

Referring to car mileage, the car formerly gave 12 miles per gal. when gasoline was good. At that time, on a test run, with the car in good condition, we carried four passengers and drove from Middletown, N. Y., to Albany, N. Y., and return, making 12 miles per gal. Later we made the same run with the same load, using the three-speed axle, and averaged 33 m.p.h., going 65 m.p.h. at times and running slowly through cities. Without the gearbox the gasoline mileage increased to 20 miles per gal.

M. C. HORINE:—One type of multiple direct gearing has escaped our notice. It was a French device employing a worm gear of variable pitch meshed, as I recall, with a roller wheel. This worm slid back and forth and gave variable gear reduction. It was a very simple device, as there were only two gears.

C. F. SCOTT:—How does Dr. McBrair's axle compare with the ordinary type of gearshift in shifting from high to second speed?

DR. MCBRAIR:—It is equally easy to shift from high to second and from second to high gear; there is absolutely no difference. We speeded to a maximum on high gear, threw into second and let the clutch in. The two passengers in the rear seat immediately proceeded toward the front, but that was all. It is possible to shift at any speed without paying any attention to the clutch; aside from the jar it works all right.

A. M. WOLF:—In the 12 to 1 low-speed set, what is the pitch of the gear teeth?

DR. MCBRAIR:—They are six-pitch teeth; in using a spiral there would be seven teeth. Better than a 12½ to 1 ratio can be obtained with a 15-in. gear, giving over a 9-in. clearance.

MR. WOLF:—With an eight-pitch gear, assuming one could go that low on tooth size, with a twelve-tooth pinion, 34-in. wheels and 13½ to 1 total gear-reduction, there is approximately a 6½-in. ground clearance. With a six-pitch gear the ground clearance would only be about 3⅛ in.

I think that one good point in Dr. McBrair's transmission is the engagement of the teeth by face contact instead of sliding the teeth lengthwise, which accounts for the ease of shifting.

MR. HORINE:—Are not gears that are clashed into mesh subjected to greater shock, with a dragging clutch, than in the sliding mesh where the pressure occurs closer to the root of the teeth instead of having the tips of the teeth take the initial shock? In other words, the shape of the teeth being somewhat rounded, in clashing them into mesh the car must actually be moved slightly forward. Is it as easy or easier to strip gears that clash, in comparison with those that slide into mesh?

DR. MCBRAIR:—That question can best be answered by showing you two of the gears that were on the car that traveled 43,000 miles. Those gears are here. In meshing the gear simply rolls in.

L. G. NILSON:—It is my opinion that it is easier to bring gears together in this way than by the customary sliding method. In sliding gears the first contact is on the corners of the teeth, with the result that the corners are often bruised or broken. If the gears are brought together radially, the strains are distributed along the whole length of the teeth. I would like to ask whether in Dr. McBrair's construction any change has been made in the pressure angle, addendum and clearance, so that when the gears are brought together the outer points will not hit too hard? It seems that the teeth should be made more pointed and not as flat as they are shown in the drawings.

W. S. HOWARD:—On bevel-gear transmissions, the Government has been holding us to full load on the reverse for 15 min. Lately, the requirement has been changed to 1 hr. at one-half load. It has been a hard matter to make gears and bearings that would meet this test, even at the reduced horsepower for the longer period.

DR. MCBRAIR:—Regarding the teeth, standard stub teeth would be better. I originally used some gears with long teeth and found they shifted with stub teeth just as well. The same thing holds true with stub teeth on a spiral-bevel gear.

MR. CLAYDEN:—I believe it is necessary and customary in all bevel-gear drives to provide a certain amount of adjustment. It is obvious that if there are more than one pair of bevel gears, individual adjustment is necessary in each successive pair.

DR. MCBRAIR:—Each individual gear is arranged for adjustment. In fact, the adjustment is the same as is used in the ordinary rear axle.

MR. NILSON:—In some of the early French cars, the Renault at least, were not the gears put in or out of mesh by tumbling them radially.

DR. MCBRAIR:—Yes, with a handle near the floor.

MR. HORINE:—In the old Packard car which had a three-speed progressive gearset, the reverse idler gear did not slide but was dropped into mesh. As far as I know this worked well, although it was a double-clash operation.

MR. GIBSON:—It appears to me that the ease of engagement when shifting gears, which is attributed by Dr. McBrair to his design of transmission, can be well understood when we consider that the peripheral speed of gears about to engage is less in the McBrair type than in the sliding type of transmission.

Present Status of Impact Tests on Road Surfaces

By A. T. GOLDBECK[1] (*Non-Member*) *Illustrated with* CHARTS AND PHOTOGRAPH

IT has been estimated that the funds available for highway construction in this country in 1920 total $633,000,000. This is more than four times the amount expended in any other previous year. It is likely that road construction will be pushed as rapidly as road material resources, equipment, hauling facilities and labor will permit. In the face of such an enormous program, it behooves us to build wisely lest we be extravagant either by too much or by too little initial expenditure for our various road systems.

Unfortunately, the necessity for such vast expenditures comes almost simultaneously with a new class of traffic which exerts a different kind of destructive effect on roads than has been exerted by traffic in the past. The heavy motor truck has transformed the road problem from one whose solution in days gone by depended upon precedent, into an exceedingly important problem of design. We must be able to design our future roads to carry known maximum loads under known conditions of sub-grade and weather, just as we are now able to design our bridge structures. We must not be satisfied with a constant cross-section irrespective of sub-grade conditions, but we must change the design of the road as nearly as practicable with changing conditions of sub-grade. At the same time we must better sub-grade conditions by more careful drainage. Recognizing these facts, and with the rational design of road surfaces as a goal, the Bureau of Public Roads has begun experiments to find out something of the fundamentals affecting road design.

Just as in the design of a bridge structure, the design of a road requires not only a knowledge of the materials in the structure and their behavior under stress, but also a knowledge of the forces acting upon the structure tending to deform it. Obviously, one of the fundamental problems is to determine just what forces tending to destroy them are being exerted upon roads.

Anyone who has stood on a hard road surface during the passage of a heavy truck has noticed the vibration set up in the pavement, indicating that the truck is exerting more or less of an impact action even though the surface be comparatively smooth. Such action is, of course, much accentuated after the surface becomes worn in spots or wavy; the impact then becomes very noticeable. Heavy loads at rest on road surfaces exert but little effect, except upon surfaces which for some reason are too soft to bear the load. Actual tests have been made on a concrete road to gain some idea of the fiber stress in the concrete directly under a heavy wheel load of a loaded truck.[2] The indications are that when a wheel load of 8500 lb. is at rest on an 8-in. concrete slab laid on a rather wet clay sub-grade, the fiber stress in tension is only about 34 lb. per sq. in. directly under the load, and since the modulus of rupture of the ordinary concrete road mixture is well over 400 and possibly as high as 600 lb. per sq. in., the danger of serious cracking of the concrete under static loads is practically nil except at the corners of the slabs.

We must turn to impact then for an explanation of some of the past failures of road surfaces under motor-truck traffic. How great can these impacts be as compared with the static weight of trucks? What impacts are likely to be exerted on road surfaces depending upon their degree of smoothness, and what effect have these impacts on different kinds and thicknesses of surface when laid on different sub-grades? These are some of the questions we must answer before we can hope to design a road rationally.

The impact tests now being conducted by the Bureau of Public Roads aim to determine

(1) The amount of impact delivered to road surfaces
(2) The effect of this impact on different types of surface

MEASUREMENT OF THE AMOUNT OF IMPACT DELIVERED

The method now being used for measuring the amount of impact delivered by trucks has been described elsewhere.[3] In brief, it consists of delivering the impact of a moving truck to a small copper cylinder, the blow deforming the cylinder a definite amount, depending upon the intensity. In these experiments a concrete pit has been constructed in the road surface and an hydraulic jack has been placed in this pit. The plunger of the jack is enlarged at the top with a platform of suitable size for receiving the blow of one wheel of the truck. The copper cylinder which measures the blow is placed under the plunger of the jack and the blow is transmitted through the plunger to the copper cylinder. The cylinders used are turned from ½-in. copper rod and are ½ in. long. A large number of these cylinders are prepared and given a special heat-treatment to make them uniform in physical characteristics. Some are selected from each lot and subjected to pressure in a testing machine, the deformation of the cylinder being noted for each load applied. In this way it is possible to check up the uniformity of the lot of cylinders and also to determine how much load is required to deform them to a definte length. The impact deforming the copper cylinder is stated in terms of the static load required to deform it to the same length.

A little thought will show that there are a number of different ways in which impact can be delivered to a road by a motor truck. The test has been arranged to approximate these different conditions. For instance, the truck while in motion is caused to fall from definite heights, striking the plunger of the jack. Again the truck is made to strike obstructions of different heights placed directly on the plunger of the jack. Several other variations of impact have been investigated.

The speed of the truck has been made one of the variables in the investigations to permit determining something of the law of the effect of speed upon the

[1] Engineer of tests, bureau of public roads, Department of Agriculture, Washington.
[2] Thickness of Concrete Slabs, by A. T. Goldbeck, *Public Roads*, April, 1919.
[3] See THE JOURNAL for September, 1919, page 210.

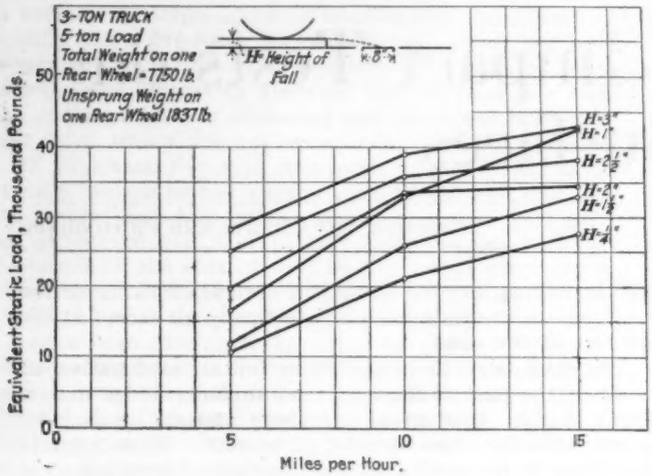


FIG. 1

impact. Different sizes and makes of truck loaded with different loads are being used. Thus far the tests have been confined to solid-tired vehicles but it is aimed to extend them to an investigation of pneumatic tires and to special types of cushioned wheels and special tires.

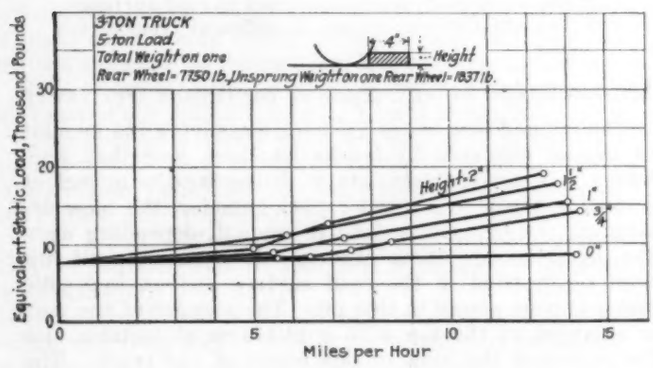


FIG. 2

The impact of the rear of the truck only has been investigated, as this impact is greater than that of the front wheels.

RESULTS OBTAINED

In this discussion no attempt will be made to treat of all the results obtained, but rather the essential features of the data will be pointed out. Some curves are given, these having been selected from a large number of test results because they, in general, show the maximum impacts that have been measured. In the tests here recorded a Class B 3 to 5-ton standard Army truck, a 5½-ton truck and a 1½-ton truck have been used. All of these trucks were supplied by the Motor Transport Corps of the War Department.

Referring to Fig. 1, which shows the results obtained with the Class B truck loaded with 5 tons of sand and having a total weight of 7750 lb. on one rear wheel, and an unsprung weight of 1837 lb. on one rear wheel, it should be noted in general that the higher the fall the greater is the amount of impact produced. The maximum impact pressure, when the truck was running

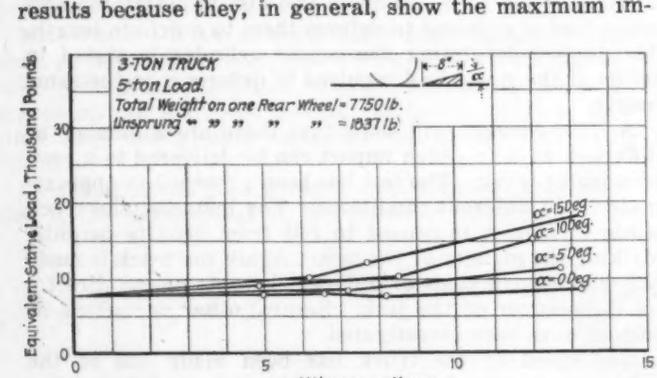

3-TON TRUCK
5-ton Load.
Total Weight on one Rear Wheel = 7750 lb.
Unsprung " " " " " = 1837 lb.
8"
α = 15 Deg.
α = 10 Deg.
α = 5 Deg.
α = 0 Deg.
Equivalent Static Load, Thousand Pounds
Miles per Hour

FIG. 3

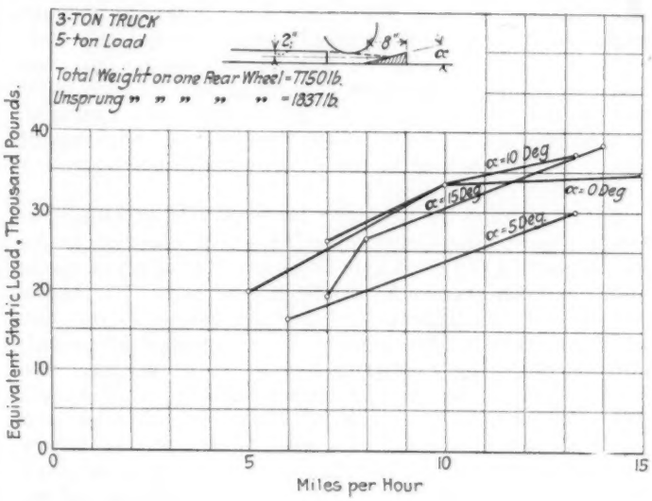


FIG. 4

15 m.p.h. and fell from a height of 3 in., was 42,000 lb. This was 5.4 times the static load pressure exerted by the rear wheel. When the rear wheel dropped from a height of only ¼ in. at 15 m.p.h., the impact pressure produced was 28,000 lb., or 3.6 times the static load pressure. It will be well to note here that the unsprung weight of this truck is large, and it will be seen that this has the effect of producing high impact pressures.

In Fig. 2 the identical truck loaded in the same manner as stated above was used, but the rear wheel was caused

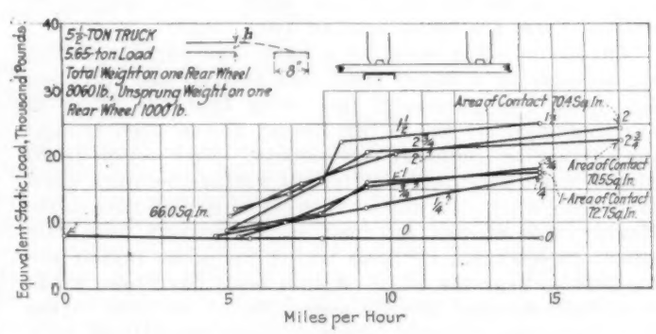

5½-TON TRUCK
5.65-ton Load
Total Weight on one Rear Wheel 8060 lb., Unsprung Weight on one Rear Wheel 1000 lb.
h
8"
Area of Contact 7.04 Sq. In.
Area of Contact 7.05 Sq. In.
Area of Contact 12.7 Sq. In.
66.0 Sq. In.
Equivalent Static Load, Thousand Pounds.
Miles per Hour

FIG. 5

to strike an obstruction which was placed on the plunger of the measuring jack. It will be noted that this condition of impact is very much less severe than that shown in Fig. 1 described above. In general the impact pressure seems to increase with the velocity and also with the height of the obstruction.

In obtaining the results shown in Fig. 3, wedge-shaped blocks were mounted on the plunger of the jack, the angle

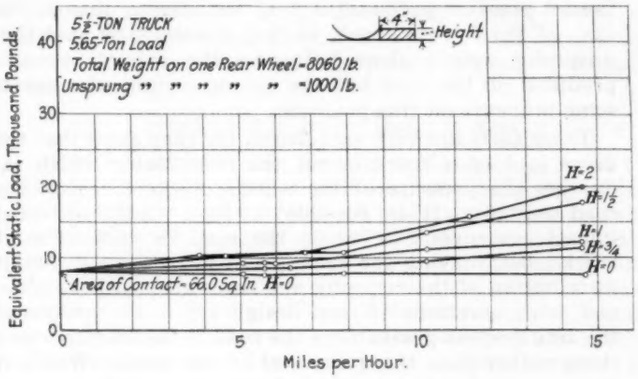


FIG. 6

of inclination of the blocks being varied for the several tests. The rear wheel of the truck simply rolled over these wedge-shaped blocks and produced pressure on the copper cylinder as shown in the curve. As would be expected, the pressure produced increases with the angle of inclination of the block and also with the speed. This condition of pressure is realized in the road surface when a truck rolls into a depression and the wheels strike the far side of the depression, and these tests show that the steeper the far side of the depression the greater will be the pressure produced on the road.

Should the depression be deep enough and the speed of the truck sufficient, the wheels will leave the surface of

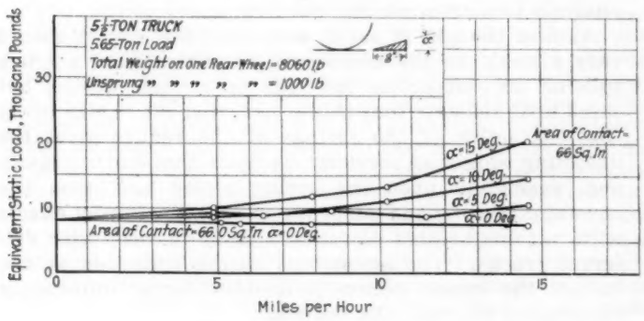


FIG. 7

the road, jumping over the depression and landing on the far side with considerable impact. This condition was tested by placing wedge-shaped blocks on top of the jack as in the previous test, elevating the point of jump-off and running the truck at such a speed that it fell on the center of the wedge-shaped block, giving pressures as shown in Fig. 4. The amount of fall in each of these cases was 2 in. It will be seen that this gives a very severe condition of impact. These tests were very difficult to make as very careful driving was required to make

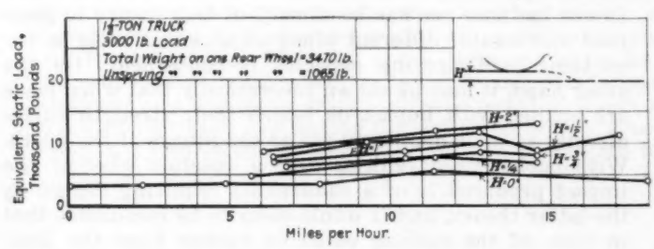


FIG. 8

the rear wheel land directly on the center of the jack. A large number of runs had to be made before results of any value at all could be obtained.

In Fig. 5 are shown results that were obtained with a 5½-ton truck carrying a load of 5.65 tons, having a total weight of 8060 lb. on one rear wheel and an unsprung weight of 1000 lb. on one rear wheel. The tests shown in this curve were obtained by running the truck at different speeds and allowing it to fall from different heights. It will be noted that the pressure increases with the speed and to some extent with the height of the fall. In the particular set of results recorded here both wheels were allowed to fall through a definite height, whereas in the other tests only one rear wheel was allowed to fall. When two wheels fall from a certain height a slightly greater pressure under one wheel is produced than when one wheel only falls through the same height.

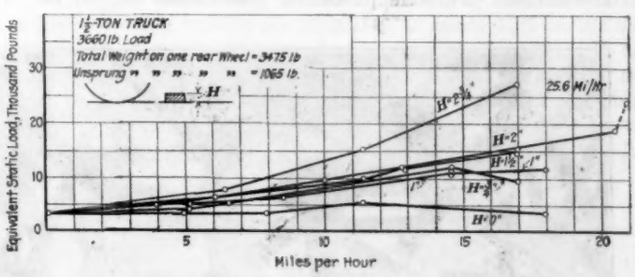


FIG. 9

In Fig. 6 the pressure measured was produced by the truck striking an obstruction placed on the jack, and this pressure is much less than in the previous case, as shown in Fig. 5. The same general tendency for pressures to increase with the speed and with the height of the obstruction is shown just as in the case of the Class B Army truck.

In Fig. 7 are shown the results obtained when the truck rolled over wedge-shaped blocks placed directly on the jack. The same general shape of curves was obtained as in the case of Class B truck, the intensity being somewhat less in this case.

The curves in Figs. 8, 9 and 10 show the impact pressures produced with a 1½-ton truck carrying a load of

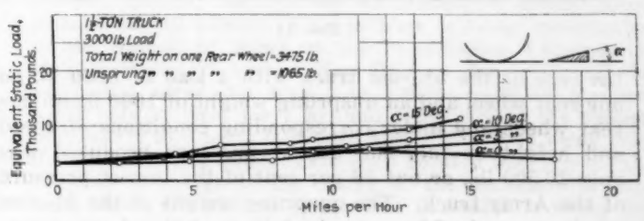


FIG. 10

3660 lb. and having a total weight on one rear wheel of 3475 lb. and an unsprung weight of 1065 lb. In Fig. 8 results were obtained with the truck falling through various heights to the weighing device. In Fig. 9 the obstruction was placed on the weighing device and in Fig. 10 wedge-shaped blocks over which the truck rolled were placed on the plunger of the device for measuring the impact pressure. These curves are of the same general shape as the preceding ones and in view of the fact that

this truck was lighter, the pressures obtained were less than those previously described.

General Discussion of the Tests

It is seen from the test results that under certain conditions the impact pressure produced by heavy motor trucks is very large, the highest pressure thus far measured being approximately 42,000 lb. when the weight on the rear wheel causing this pressure was only 7750 lb. It was pointed out that the unsprung weight on one rear wheel of this truck was 1837 lb. In the case of the 5½-ton truck, which has an unsprung weight of 1000 lb., it has been shown that the impact pressures produced were very much smaller than in the case of the Class B Army truck. Considering a specific case, when the Class B Army truck, which had a total weight of 7750 lb. on one rear wheel, an unsprung weight of 1837 lb. on one rear wheel, fell from a height of 2 in. at a speed of 15 m.p.h., the impact pressure produced was about 34,500 lb. In

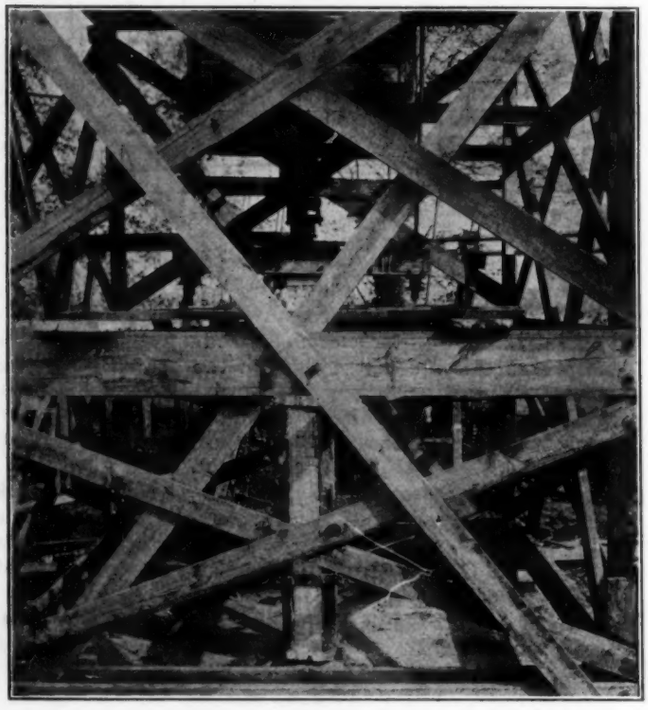


Fig. 11

the case of the 5½-ton truck with a load of 8060 lb. on one rear wheel and an unsprung weight of 1000 lb. on one rear wheel, and under corresponding conditions of speed and height of fall, the impact pressure produced was only 23,500 lb., or but 68 per cent of the impact pressure of the Army truck. The unsprung weight of the 5½-ton truck was only 56 per cent of that of the Army truck, whereas the gross load carried on the rear wheel was slightly larger in the case of the Class B truck. The indications are, therefore, that a light unsprung weight tends to decrease the impact of a truck on the road surface.

Referring to Fig. 9, giving results for a 1½-ton truck having a total weight of 3470 lb. on one rear wheel and 1065 lb. unsprung weight on one rear wheel, the impact pressure at a speed of 15 m.p.h. and with a height of fall of 2 in. was approximately 14,000 lb. per sq. in. It will be noted that the unsprung weight of this truck is practically the same as that of the 5½-ton truck and the impact pressure produced is very much lower than in the case of the 5½-ton truck, so that it cannot be said that unsprung weight alone influences the impact pressure produced on the road but the sprung weight also exerts some influence on this pressure.

These facts are very significant, for they show that the gross load of a truck is not the only factor which influences the pressure of the wheels of the truck on the road surface. It is possible to have vastly different impact pressures exerted on the road by two different trucks, both having the same gross weight but different distribution of their sprung and their unsprung weights, and when questions of road design are to be considered the actual wheel pressure on the road is the all-important thing rather than the gross load of the truck. Would it not seem logical to take these facts into consideration in framing legislation dealing with the restriction of maximum sizes of motor trucks on roads, and moreover, do these facts not open the way toward a more equitable system of license fees than the more or less arbitrary systems based on gross load, carrying capacity or horsepower now in use?

The effect of the speed of trucks on the amount of impact produced on road surfaces is indicated by these tests. It has been stated that the impact of vehicles on roads varies as the square of the speed, but the present tests indicate that within practical speed limits this is not the case. In the results obtained thus far the impact on the road varies with some power of the speed, this power being, however, less than two and extending down as low as one. The present data do not warrant a close analysis to determine this relation.

At first thought it would seem that the impact should vary directly as the amount of the drop when a truck rolls off an obstruction and falls on a road surface, but these tests indicate that this is not true, the reason being that the action of the springs of the vehicle gives the unsprung weight an acceleration above that due to gravity and, depending upon the spring action and upon the amount of sprung and unsprung weight, the impact effects with various heights of fall are likely to vary with different trucks. The amount of spring deflection at the instant the impact occurs is another factor influencing the amount of impact on the road.

Having determined the amount of impact exerted on surfaces by trucks under these artificial conditions, the next question arises as to what impacts are actually produced on road surfaces of different degrees of roughness. Undoubtedly a road having a rough surface will be subjected to greater impact than a smooth road. It is hoped that it will be possible to obtain data in this connection within the coming year by special equipment now being constructed.

What use shall be made of the results of the impact tests in the design of road surfaces? The theory for the design of beams under static loads is to the effect that the strength of the beam varies as the square of the depth. In one instance use has been made of this theory to place road surfaces of different kinds on an equal basis so far as their load-carrying capacity is concerned. On the other hand, it may be shown theoretically that when loads are applied with impact on beams their strength varies directly as their depth and not as the square of the depth. With rubber-tired vehicles it is a question whether the impact produced is of a suddenness requiring design by the latter theory, and it would seem to be reasonable that in view of the cushion effect of rubber tires the load-carrying capacity of the slab will vary as some function

between D and D^3. When the proper theory to use is determined, knowledge of the amount of load applied by impacts will permit of actually designing roads to sustain these loads properly.

Effect of Impact on Road Surfaces

Having obtained the amount of impact exerted by trucks, the next question is that of the damaging effect of impacts on road surfaces. We are attempting to gain some information on this point through a series of tests now under way. We have constructed a number of slabs 7 ft. square laid directly on the sub-grade. Half of these sections are laid on a sub-grade which is purposely kept wet, and half of them are on a well-drained sub-grade. The sections thus far constructed include concrete in depths varying from 2 to 10 in., and brick constructed on varying thicknesses of concrete base. Various kinds of brick have been used, including repressed, wire-cut lug and vertical fiber brick. We have used monolithic, semi-monolithic and sand-cushion construction; also both Portland cement grout and bituminous mastic fillers. One section is laid on a bituminous mastic cushion with a bituminous mastic filler. In other sections the brick have been laid directly on the sub-grade and in still others on a prepared macadam base. We are testing these slabs by an impact machine designed to represent the conditions existing on the rear wheel of a truck. This machine, which is shown in Fig. 11, has an unsprung weight of 3000 lb. and will carry a sprung weight of 9000 lb. These weights correspond approximately to those that would exist on the rear wheel of a 7½-ton truck. The lower end of the sprung weight is shod with a solid rubber tire and the whole weight will be raised to a height such that when allowed to fall the impact delivered will be one that might be delivered by a 7½-ton truck. The observations will consist of noting the behavior of the surface under repeated impacts of this machine and will also include measurements of deflection of the surface. Nothing can be said of the results at the present as the tests have not progressed to that extent. We aim to continue these investigations with bituminous surfaces laid on concrete bases, using a 1:3:6 as well as a 1:1½:3 base. In addition, broken-stone bases will be used under the bituminous surfaces.

With the completion of these tests it is expected that sufficient data will be accumulated to place the design of roads on a much sounder basis than at present. It is hoped that these results, combined with the results of still other investigations, will finally lead to a suitable method for determining with certainty on road types and cross-sections for definite sub-grade and load conditions.

AUTOMOBILE EXHAUST GASES IN TUNNELS

TO obtain information as to the amount and composition of automobile exhaust gases in tunnels, subways and other confined spaces through which passenger cars and motor trucks must pass, the Bureau of Mines has undertaken a series of tests at its Pittsburgh experiment station. The object of this study which is being made on approximately 100 passenger cars and motor trucks is to secure data for the ventilation of tunnels such as the 8000-ft. tunnel which is to pass under the Hudson River between New York City and New Jersey and a proposed tunnel 6000 ft. long between Boston and East Boston. The ventilation of such tunnels is a serious matter on account of the poisonous nature of the automobile exhaust gases, the constituent which has been responsible for the death of persons in garages where engines have been run with the doors and windows closed being carbon monoxide. The gas which is colorless and tasteless and gives off no odor has been responsible also for the death of many miners after mine fires and explosions. The smoke issuing from the exhaust of an automobile is not carbon monoxide, although where there is smoke this gas usually is present, the amount varying under different conditions of running. The adjustment of the carbureter is the principal cause for this variation which ranges from practically nothing in a very lean mixture up to 10 per cent with a rich one.

Very few tests have ever been made on cars taken from the street and tested in the condition under which they were operated. The only way to obtain this information is to run a series of tests on the road under exactly the same conditions as will prevail in tunnels using cars and trucks of various sizes so that average results can be obtained for each type of vehicle. The work at the Bureau of Mines Experiment Station was started in December and twenty-four passenger cars and motor trucks had been tested to March 1 of the present year. In making the test an accurately graduated tube containing the gasoline to be used is attached to the carbureter and another apparatus for collecting the gas sample is attached to the exhaust pipe by a rubber tube. The car is then taken to the test course and run for exactly 1 mile at the required speed. Tests are being made on a level stretch of road and up and down a 2 per cent grade at speeds of 6, 10, 15 and 20 m.p.h.; also with the engine racing, idling and accelerating to reproduce conditions in a tunnel when it is crowded with cars starting up after a blockade in the traffic. While the run is being made the gasoline is accurately measured and a sample of gas collected. This sample is sent to the laboratories of the Bureau and carefully analyzed for all constituents, the number of cubic feet of carbon monoxide which is given off by the car being calculated from the results.

As only very small percentages of carbon monoxide are needed to render a person unconscious and 1 per cent in the atmosphere will produce death very quickly, it is necessary that data be secured on the largest allowable percentage of carbon monoxide that a person can breathe for several hours without any ill effects. This problem is being investigated by the Bureau of Mines at the Physiological Laboratories of Yale Medical School at New Haven. Practically all the authorities agree that from 1 to 3 parts in 10,000 are perfectly safe at least for 1 hr. and a few are of the opinion that even 5 to 6 parts is not too high. The work being done should determine which figure shall be used and provide the engineer in charge of the design of the tunnels with data from which the amount of air that is needed to sweep out the exhaust gases from a tunnel can be properly calculated.

The exhaust gas tests will be continued throughout the summer to ascertain whether less carbon monoxide is produced when a machine operates in warmer weather. The average of the twenty-four vehicles tested thus far showed that from 20 to 30 per cent of the heat in the gasoline was lost in the form of unburned gases in the exhaust.—A. C. Fieldner in Bureau of Mines Monthly Report on Investigations.

Addresses at the Chicago Aeronautic Meeting

THE meeting at Chicago on Jan. 13, although designated as an Aeronautic Meeting of the Society, was in reality a Mid-West Section meeting. All arrangements were made by the Section and it was therefore natural that emphasis should be placed upon the importance of the Sections by Past-president Charles M. Manly and General Manager Clarkson in their remarks. In addition W. T. Van Orman gave an interesting account of the National Balloon Race held in the fall of 1919. This last is printed elsewhere in this issue of THE JOURNAL, while the other two addresses are given below.

E. H. Sherbondy gave a very interesting and valuable address on supercharging aeronautic engines. The data that Mr. Sherbondy has in hand are very comprehensive, and it is trusted that a large portion of these can be published in the JOURNAL at an early date.

ADDRESS OF PAST-PRESIDENT MANLY

THERE is one thing that I would like particularly to say, a thing that is very near to me. I have spoken of it in my recent term of office as President of the Society. It is the importance of the Sections. You have here the very nucleus of what I see as the big work of the Society. The Sections must be developed into strong-going main branches of the Society and the way to do that is to give them all the punch that can possibly be given them in connection with the presentation and and discussion of technical papers. It is impossible to attempt to carry on the work of the Society by having a few papers presented at the annual meetings, or by having simply a few papers contributed to THE JOURNAL from time to time. The thing that we most need to build up the work of the Society, to the position that it must be built up to, is to have competition among the members for the honor of presenting papers at the Section meetings and then competition among the people that hear those papers in really discussing them from a technical point of view.

The fact that a paper on any subject is to be presented should be an immediate signal to everyone who has any ideas on that same subject to attend the meeting, and not to attend it with the idea that he is going to gather in information but not give out any. A man who does that usually keeps out a whole lot more than he keeps in. The way to get the real advantage of the work of the Sections is to carry on this active presentation of the papers and the active discussion of them, so that in the selecting of papers for THE JOURNAL, we will get the very best papers it is possible to get.

This work of the Society of Automotive Engineers is one of the biggest things that we have in the engineering world, and it will grow to tremendously larger proportions than it has at the present time. My own feeling is that the work of the automotive engineer has just begun. We are going to have, I think, inside of the next ten years, some 20,000 members of the Society of Automotive Engineers. There will be enough automotive engineering work to be done within the next ten years to call for that many more engineers. Whether we shall have them all cooperating in the work of the Society, is going to depend very largely on the work of the Sections. I hope, therefore, that the different Sections will awake to their real opportunity in connection with the carrying on of this work of the Society. We shall see very important developments in connection with aircraft. We have now come to the stage where the commercial end has to be developed to have any business at all. The Government is not likely to be calling for any large quantity of machines. It will, no doubt, call for a number of machines of different types to maintain the process of building up the aviation service, but the real work of the automotive engineer in the aircraft field must be in connection with commercial aircraft development and operation, and the operating side will be as large as, or larger, than the actual building side.

In the building work we have much to unlearn. The past several years of aircraft development have been devoted exclusively to perfecting the machine as a war machine. Recently we have been working toward a commercial development. There is a tremendous amount to be done in connection with the commercial development. One of the most important things in connection with it is that we shall do our part to get landing fields built. We cannot operate airplanes without landing fields any more than we could operate automobiles without roads, or ships without harbors. The aircraft is today in the same fix as the "Soviet Ark"; it is on its way somewhere, but apparently has no harbor to go into. It is drifting around. The appointed harbor has not been designated, at least as far as we know. The aircraft business has to have landing fields just as that ship or any other ship has to have a harbor to go into. If all of our harbors were suddenly taken away, shipping would be in a pretty bad fix; and if all of the automobiles at the beginning of the automobile development had had to operate on country roads and not been usable in the cities, there would have been a very heavy retarding effect on the development of the automobile. We must have landing fields. So it is very important that everyone connected with automotive work do all he can toward assisting the development of them to help along the aircraft work.

The other thing in connection with aircraft work that we all have of necessity to be interested in is to try to get the National Government to take necessary action to provide a unified system of control, so that the states and municipalities will not commence passing all kinds of restrictive laws that will hamper the development work and the actual operation of the machines.

Some excellent plans have been developed in connection with that by the aviation commission that went over to Europe last year under the leadership of Assistant Secretary of War Crowell. These have been presented to Congress in the form of proposed legislative enactments. If the suggestions are carried out, it will be possible to put into effect a really constructive plan of operation that will prevent the passing of all kinds of municipal and State regulations to hamper aircraft operation and hold it back for very many years. The most important thing in automotive work in the way of immediate development is, I think, the motor-truck business. I think that we have not even commenced to get a vision of it. We have a few hundred

thousand motor trucks running in the United States. There will have to be several millions running before the country is really properly motorized. We have them operating now under a great many conditions. I think that within the next few years we shall see a tremendous development in the motor-truck business, not only in the building of more motor trucks of more diversified kinds for the different work, but also the building up of very complete data and systems of operation that will really give us the same kind of ability to predict the cost of operation that we now have in connection with predicting the cost of construction, or that we now have in connection with railroad operation. So that in the field of motor-truck work, I think that the next ten years will see a good many thousand engineers added, both from the designing and constructing end and from the operating end. Chicago, with its tremendous amount of traffic, should form a very active field for the work of the Society, if the Section here is alive to its opportunities, and that means it is the men who compose the Section that really must have a true vision of what the opportunities are in connection with the Section.

When we come down to it, this matter of vision is really the thing that is most important to all of us. If we have not vision in regard to the future, we will not really exert ourselves in a big way to do the big things that lie before us, and if we have not vision, we ought to acquire it. The vision I see of the work before the automotive engineer for the next ten to twenty years is one of the most fascinating things that a person could possibly contemplate.

I hope that the Mid-West Section will see the vision before it and really work toward the building up of a very active, virile Section here that will make the work of the Society, in this Section, of the great importance that it should be.

ADDRESS OF GENERAL MANAGER CLARKSON

I WANT to supplement somewhat the excellent outline Mr. Manly has just given of the present and prospective work of the Society. I think there is great suggestive value in what he said.

The Council of the Society as a whole concurs unreservedly in the view that Mr. Manly has given as to the importance of the Sections. The point of the matter is that in the Sections there are not only more frequent opportunities for the members to get together but there is more intimate affiliation between them at Section meetings.

A distinct advance has been made in the matter of the actual adoption of valuable standards in tractor work. There is a more general appreciation of the importance of certain types of standards and of the feasibility of formulating and establishing them. With reference to the standards work in general, the Divisions of the Standards Committee have been working well. The reports presented, and accepted for the most part, at the meeting of the Society in January of this year, were more numerous than in any half-year theretofore, and contained much of value to the automotive industry.

Our real work is the securing and disseminating in good intelligible form of technical information, either by way of comprehensive statement of old matters or in connection with anticipating what is coming in the way of development to be reduced to practice. I think we all want to keep in mind constantly that that is our work, the nucleus from which we can be of greatest value to the members individually, the industry as a whole, and in turn the Nation.

There is much broad cooperative work to do. One phase of it has come before the Mid-West Section, in the matter of the possibility of an engineering club being established in Chicago and a building erected to house it. The engineering societies will have to work together more and more as time goes on, because it is obvious that they have much in common, and that which they have in common is of great importance in engineering generally and in connection with the status of the engineer in the various communities and the country as a whole. The theory and logic of the joint procedure are analogous to the common sense of the combined standards work in the different automotive fields, motor-truck, passenger-car, aircraft, motor-boat, farm-tractor, farm engine and isolated electric-lighting plant. The Society is doing and would do in any event those things which apply very largely to all the automotive engineering fields. There are subjects in which the S. A. E. is vitally interested, that are of interest to other engineering organizations and to various Government bureaus. There must be some medium by which all of the bodies actually concerned can work together, avoiding duplication of effort and unnecessary expenditure of money and securing more effective results. There must be also one channel through which we can take up matters of standardization with foreign countries. International standardization is right before us.

ORVILLE WRIGHT AWARDED THE JOHN FRITZ MEDAL

THE John Fritz Medal will be awarded this year to Orville Wright for achievement in the development of the airplane. The presentation of the medal will be made in the auditorium of the Engineering Societies Building, New York City, on the evening of May 7. B. B. Thayer, chairman of the board of award for the present year, will preside. Major-general George O. Squier, U. S. A., chief signal officer, and E. A. Deeds, president, Domestic Engineering Co., Dayton, Ohio, are scheduled for addresses. The actual presentation of the medal will be made by Comfort A. Adams, a member of the board which made the award.

The medal was established in 1902 on the eightieth birthday of John Fritz, by professional associates and friends as a means of perpetuating the memory of his achievements in industrial progress. It is awarded annually for notable scientific or industrial achievements and is accompanied by an engraved certificate stating the origin of the medal and the specific achievement for which the respective award is made. The board of award is composed of sixteen members, four each from the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers.

The first award of the medal was made to John Fritz at a dinner given to him on his eightieth birthday, Aug. 21, 1902. Among those who have received the medal since that time are Lord Kelvin, George Westinghouse, Alexander Graham Bell, Thomas A. Edison, Robert W. Hunt, Prof. John E. Sweet, Dr. James Douglas, Dr. Elihu Thomson, Dr. Henry M. Howe and General George W. Goethals. The present award is the second which has been made to a member of the Society of Automotive Engineers and it is hoped that a large number of the members will be present to felicitate Mr. Wright on the evening of May 7.

MAJOR SCHROEDER'S RECORD ALTITUDE FLIGHT

MAJOR SCHROEDER'S successful altitude flight was the result of a long series of important tests in engineering development by the engineering division of the Air Service. This series of tests disclosed problem after problem which had to be overcome in some manner before further advances could be made. Some of the troubles were the difficulty of delivering fuel to the carbureter against its varying pressure; difficulty of cooling at high altitude and of raising the boiling point of the water, and the problem of providing a drain-valve to let the water out of the radiator at great altitude in case the engine stopped, so that the engine and cooling system would not be ruined by the water freezing; at the same time it was necessary for this valve to be arranged so that it would not itself freeze, thus making it impossible to operate it. Major Schroeder had to invent and design special goggles which would not freeze over in the intense cold at great heights. A special instrument had to be developed to show the pilot how to handle his exhaust bypass gates; in other words, how to control the supercharger pressure in his carbureters without the need of making any calculations.

Much trouble has always been encountered from preignition when running with a supercharger, due to the fact that the air delivered to the carbureter is at a very high temperature. Future designs of superchargers will provide additional intercooling between the compressor and the carbureters. The fuel-feed system had, prior to Major Schroeder's record flight, operated very satisfactorily, but in spite of this fact it was necessary for him to close the vents in the gasoline tank and pump pressure into them with a hand air-pump to help the fuel pumps deliver the fuel at the extreme altitudes. To reduce the preignition which it was expected would be encountered on this flight, a specially prepared fuel was provided by Thomas Midgely, Jr., who has been developing "anti-knock" fuels for Mr. Kettering. This fuel proved to be of great assistance in this flight, as it caused the engine to run much more smoothly.

The supercharger used was the original General Electric supercharger designed by Dr. Sanford A. Moss and originally tested on Pike's Peak in 1918. Therefore, it is not surprising that no good means had been provided for blowing off the exhaust gases which issue from the turbine, consequently throughout all flights the exhaust gas has bothered the pilot to a certain extent, due to the fact that it sweeps past his face. No way has been found to date to carry the exhaust entirely clear of the occupants of the machine. On the record flight it seems that the gases expanded more rapidly as they issued from the turbine in the thin air at great altitude and in even larger volume swept past the pilot's face and, judging from the doctor's report the carbon-monoxide poisoning gave Schroeder more trouble than the lack of oxygen.

In military work an automatic oxygen-feed apparatus is provided for the pilot which regulates the amount of oxygen in proportion to altitude, so that the pilot need not think of making any adjustments. Major Schroeder had been in the habit of using a simple rubber tube from the neck of the oxygen flask to his mask in such a manner that he could adjust the flow by hand, as he has often had trouble with the oxygen freezing and stopping at great altitudes. On his record flight he knew he would be up for a long time and desired to use the automatic apparatus as long as he could and believed it would work to about 29,000 ft. He, therefore, took one bottle of oxygen connected through the automatic oxygen feed and one connected direct. However, finding that the automatic apparatus did not work at all, he had to start using the emergency bottle at about 18,000 ft., thinking that it would last long enough for him to make the record. But, probably due to the large amount of exhaust gas he was breathing, he had to use an excess amount of oxygen. This, of course, resulted in his reaching the end of the supply sooner than he expected.

It is an interesting fact that the instrument which shows the pilot what pressure his supercharger is delivering to the carbureter, showed a pressure close to that of sea level even when he was at the highest point of the flight. The operation of the supercharger was excellent throughout the flight and was found to be in good condition afterward.

Major Schroeder states that he actually reached a warmer temperature at the top of his climb. The coldest temperature recorded was about minus 67 deg. fahr.; 2000 or 3000 ft. higher, at the top of his climb, the temperature was 4 deg. higher. He encountered the usual strong west wind, which he has in every case encountered at altitudes above 25,000 ft. He believes the velocity of this wind to be close to 175 m.p.h., judging by the rate at which it drifted his machine eastward, although he was headed west and climbing at an extraordinarily high air speed due to the use of the supercharger.

At low temperature the exhaust gas from the engine became snow white from the freezing of the vapor in it. Long white clouds formed by this exhaust are visible from the ground on a clear day, such as that on which Major Schroeder's flight was made. This results in ice forming on all the wires and struts coming in contact with the stream of the exhaust.

When Major Schroeder's oxygen supply finally failed, he raised his goggles to see more clearly to try and "coax" more oxygen from one or the other of the tanks. Unconsciousness suddenly overtook him but not before he reached for the switch and put the machine into a spiral. He intended to make one steep spiral which would bring him down to about 20,000 ft. above the ground, where he expected to recover, but, although he believed after his fall that he had succeeded in doing this, as a matter of fact, the plane fell like a shot pigeon down to about 3000 ft. above the ground, where Schroeder regained consciousness, "righted" the plane, and although he was still semi-unconscious and could scarcely see at all due to the chilling of his eyes, he had the presence of mind to open the vents in the gasoline tanks so that the engine would continue to get fuel and run. Having succeeded in opening only one switch instead of two, which are present in all Liberty ignition systems, his engine had been running practically wide-open throughout the fall. This kept the water from freezing in the cooling system and gave him the use of the engine after his recovery.

Three of the four gasoline tanks which probably had a plus pressure of several pounds in relation to the surrounding atmosphere at the top of the climb, had collapsed, one of them almost totally due to the fact that at the bottom of the fall, conditions had changed so that there was a minus pressure inside of several pounds. This is why it was necessary for Major Schroeder to open the vents in the tanks to be able to deliver fuel to the engine to get to a suitable place to land.

The military value of the supercharger will be very great. It will greatly increase speed of airplanes at altitudes, enable them to go much faster than they can near the ground. It will be useful for extreme altitude photography because the photographer will not be hampered by attack if the plane goes high enough. An airplane with a supercharged engine will be valuable to carry dispatches or a high ranking officer over great distances in a very short time. Superchargers, when applied to a heavy bomber, will enable this type of machine to reach a ceiling well above enemy anti-aircraft gun-fire and in fighting planes will greatly increase speed and climb.

Commercial use of superchargers will enable heavy passenger or express-carrying airplanes to climb over the highest mountains or over thunder storms with comparatively low-powered and low-priced engines. It is felt that passenger-carrying airplanes can be provided with a supercharger and an air-tight cabin for the passengers, so that the supercharger can keep the air in this cabin at a density and temperature which will make it practically comfortable for all passengers, and, at the same time the airplane can fly at extreme altitudes at very much greater speeds.—Air Service News Letter.

ACTIVITIES OF THE SECTIONS

EVERY one of the eight Sections of the Society has had a program in the season that has been well worth while. During the war and for some time afterward many members were temporarily engaged in work which either took them overseas or sent them to other cities, thereby keeping them from their home cities. This fact cost the Sections, for the time being, the loss of a number of their most prominent and enthusiastic workers, and it is only within the last few months that some of these have been able to resume their usual activities to the full extent.

The meetings held in the past year have progressed most favorably, however, both with reference to attendance and with regard to the quality of subjects presented. Most of the Sections are interested in all phases of automotive engineering and the papers presented at their meetings have included subjects connected with passenger cars, motor trucks, tractors, aircraft, motor boats and stationary engines. The talks have been given by designers, factory managers and users, and have ranged from subjects of general interest, such as japanning practice, to those of special value to the members in a single automotive field, such as the consideration of variable-pitch propellers for airplanes or the relative advantages of various types of tread for tractors.

It has been the usual practice to start the technical meeting with a dinner, and this has proved a marked success, both because of the more intimate acquaintanceships formed, and because it makes it unnecessary for one to go home for a hurried dinner and later return to town for the meeting.

The Society Nominating Committee, whose function it is to propose the names of men to be voted upon for service as officers of the Society for the next year, is composed of Members severally elected by the Sections, and three Members elected by the Society at large. This places considerable power in and responsibility upon the Sections.

It is becoming increasingly evident that a member of the Society who does not belong to his local Section as well, is missing much of benefit and pleasure. Since the Society is national in its scope, it is manifestly impossible for it to hold frequent meetings. A great portion of the work leading up to the Annual and Summer Meetings of the Society must be done by the various Committees and by the Sections.

Because the Sections cover limited geographical territory respectively, it is possible for them to hold meetings approximately once a month, and the consequence is that those who attend these more frequent meetings have an opportunity to hear and to present papers and to discuss the subjects presented in much greater detail than can be done in the infrequent meetings of the Society, where the time is inadequate for anything like a complete consideration of the many subjects broached.

The Pennsylvania Section held another successful meeting on Thursday evening, March 25, at the Engineers' Club of Philadelphia. Commander H. C. Richardson, U. S. N., was the speaker, his paper being on the engineering features involved in the design of machines for high-altitude flying. He explained the use of the supercharger, which enables the engine to develop the same horsepower at a high altitude as it does on the surface of the earth. He showed by graphic charts the characteristics of an engine in connection with the variable-pitch propeller, and pointed out the fact that with the pitch of the propeller blade constant, the speed of revolution of the propeller and consequently of the engine would increase with the rarification of the air at a distance from the surface, and that these conditions would decrease the efficiency and ultimately wreck the engine.

With a propeller, the pitch of which can be changed as the machine rises, this condition can be changed, the increased angle at which the blades are set causing the speed of the propeller to decrease, and giving a greater efficiency than could be had at the same altitude with a propeller of less pitch and greater speed. The suggestion was also made that a similar governed effect on the engine might be produced by shifting gears. This would allow the propeller to travel at a greater number of revolutions, but would permit the engine to run at a speed which would not be detrimental.

The discussion which followed lasted for some time and indicated the interest in the subject on the part of those in attendance. After the discussion of the speaker's paper, Chairman Brumbaugh suggested that Commander Richardson give an account of the flight to the Azores of the NC-3. The story which followed, and which was most enthusiastically received, was in itself of sufficient interest to make the meeting well worth while, and, combined with the technical paper, made the evening a success in every way.

The Cleveland Section held on March 26 in the Lattice Room of the Statler Hotel a meeting which began with a dinner at which about sixty were present. The business and technical sessions were attended by 125 or more.

J. H. Hunt, research engineer of the Dayton Engineering Laboratories Co., gave a most interesting paper on the advantages of Battery Ignition. This brought forth a lively discussion from the magneto engineers. There was so much to be said on both sides of the question that it was thought best to divide the discussion of the two ignition systems into two meetings rather than attempt to cover all of the ground in one. A formal presentation of the magneto side will be made at the next meeting of the Section to be held in the latter part of April. The Cleveland Section is looking forward to a large attendance on the part of the representatives of both the battery and the magneto manufacturers.

Nominations for Officers

In addition to the nominations for Section officers which were printed on page 197 of the March issue of THE JOURNAL, the following have since been received. **This makes the list complete for the eight Sections.**

INDIANA SECTION

Chairman .....Stanley Witworth
Vice-chairman .....D. L. Gallup
Secretary .....E. B. Reeser
Treasurer .....J. E. Padgett

MID-WEST SECTION

Chairman .....George T. Briggs
Vice-chairman .....Dent Parrett
Secretary .....L. S. Sheldrick
Treasurer .....Walter S. Nathan

MINNEAPOLIS SECTION

Chairman .....A. W. Scarratt
Vice-chairman .....R. S. Kinkead
Secretary .....C. T. Stevens
Treasurer .....J. S. Clapper

OBITUARIES

HERMAN J. HASS, vice-president and general manager of the Peru Auto Parts Mfg. Co., Peru, Ind., died in that city on Feb. 12, following a week's illness with pneumonia, aged 57 years. He was born at Cincinnati, Dec. 23, 1862, but in 1870 his parents removed their home to Mishawaka, Ind., and it was there that he received his education and served his early apprenticeship in the plant of the Perkins Windmill Co. In 1886 he became assistant superintendent of the H. A. Lozier Co., Toledo, Ohio, and in 1895 was advanced to the superintendency of the Canadian plant of this firm at Toronto, Ont. From 1901 to 1907 he was connected with the E. R. Thomas Motor Co., Buffalo, and following this was chief engineer of the Standard Gas & Electric Power Co., Philadelphia, until November, 1909. He then removed to Peru, Ind., becoming general manager of the Peru Auto Parts Mfg. Co. and continuing his connection with this company until his sudden demise.

Mr. Hass was widely known among manufacturers throughout Indiana and other States and was a member of several fraternal orders. He was elected to Member grade in the Society, Feb. 16, 1909.

EMIL M. LOWY, technical representative of the Rhineland Machine Works Co., New York City, died Jan. 15, 1920. He was born April 2, 1884, at Hermannstadt, Hungary, and received his preliminary and technical education in Budapest and in Charlottenburg, Germany. From 1906 to 1908 he was designing engineer of locomobiles and steam shovels for the Isthmian Canal Commission, Panama, afterward being connected with several different firms in engineering and managerial capacities until 1911, when he entered the employ of the Rhineland company. His special interests and training were in steel and steel products. He was elected to Member grade in the Society, March 14, 1912.

NELSON S. PRINGLE, engineer of tests for the Autocar Co., Ardmore, Pa., died of pneumonia, Feb. 2, 1920, aged 34 years. He was born at Newark, N. J., Nov. 19, 1885, and following his preparatory education attended Stevens Institute of Technology, Hoboken, N. J., graduating as a mechanical engineer in 1911. From 1901 to 1907 he was export business manager for the New York Export Co., a firm that was largely responsible for the introduction of American automobiles to the Far East, his activities in this connection being mainly of an engineering nature. His connection with the Autocar Co. was immediately subsequent to his graduation in 1911. He was elected to Member grade in the Society, Nov. 22, 1912.

ALFRED C. ROYCE, engineer of tests for the Ordnance Department at the Standard Steel Works Co., Burnham, Pa., died Feb. 6, 1920, aged 29 years. He was born Aug. 26, 1890, at North Tonawanda, N. Y., and following his preliminary education attended the University of Buffalo, specializing in chemistry. His subsequent connections with the Lackawanna Steel and the Donner Steel companies at Buffalo equipped him with a practical knowledge of steel manufacture and methods of testing which was further applied for a short period preceding his entrance into the Army with the Pierce-Arrow Motor Car Co. of Buffalo as an inspector of steel castings. He was a junior member of the American Society for Testing Materials and a member of the Metallurgical Society of America. He was elected to Associate Member grade in the Society, Aug. 25, 1919.

PERSONAL NOTES OF THE MEMBERS

Walter P. Chrysler has been appointed general manager of the Willys-Overland Co., Toledo, Ohio. He was formerly president of the Buick Motor Co., Flint, Mich., and vice-president in charge of production of the General Motors Corporation.

Ray T. Middleton has been elected vice-president and director of sales of the Kelly Metals Co. with headquarters at Chicago. He was formerly general representative of the Standard Steel Castings Co., Cleveland.

William H. Miller, who was formerly consulting engineer of the Flexible Armored Hose Corporation, Buffalo, has been appointed general manager and director of sales of the International Metal Hose Co., Cleveland. This is a new organization formed by Mr. Miller to manufacture different types of metal hose and tubing for the several branches of the automotive industry.

E. R. Morse has been appointed manager of the Philadelphia office of the Morse Chain Co., which has just been opened. He was formerly located at the company's main office at Ithaca, N. Y.

Herbert M. Smith has resigned his position as laboratory engineer with the Aluminum Manufactures, Inc., Cleveland, to accept a position on the sales force of the American Six Sales Co., also of that city.

Louis Steinfurth, Jr., who was formerly with the Cleveland Automobile Co., Cleveland, has accepted a position in the engineering department of the Paragon Motor Car Co., Connellsville, Pa.

REVISED EDITION OF SERVICE BOOKLET

A PAMPHLET giving the service records of the members of the Society was compiled and distributed at the 1919 Annual Meeting of the Society. Since that time a number of corrections have been received. A revised edition was distributed at the Annual Meeting this year. Those members who did not attend the dinner at the Hotel Astor and consequently failed to receive copies of the booklet can secure them upon application to the office of the Society in New York City. As the supply is somewhat limited it is hoped that members who received copies will not ask for additional ones.

Applicants *Qualified*

The following applicants have qualified for admission to the Society between March 6 and March 31, 1920. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (Aff Rep) Affiliate Representative; (E S) Enrolled Student; (S M) Service Member; (F M) Foreign Member.

AUSTIN, RALPH W. (M) second vice-president and factory manager, Gramm-Bernstein Motor Truck Co., *Lima, Ohio.*

AYR, DAVID (M) general manager, Machine Stamping Co., Ltd., 1209 King Street West, *Toronto, Ont., Canada.*

BELL, ERNEST ALFRED (F M) general manager and chief engineer, Globe Motor & Taxi Co., South Melbourne, (mail) 31 Harold Street, *Upper Hawthorn, Melbourne, Australia.*

BREESE, ROBERT P. (M) engineer, Loening Aeronautical Engineering Corporation, *New York City,* (mail) 251 East Sixty-first Street.

BROWN, ARTHUR T. (J) designing engineer, Dodge Engraving Co., *Boston,* (mail) 75 Glen Road.

BRYAN, WILLIAM JAMES (A) sales manager, Budd Wheel Corporation, Philadelphia, Pa., (mail) 1252 Book Building, *Detroit.*

CHAMBERS, CLINARD F. (A) purchaser of automobiles and accessories, Texas Co., *New York City,* (mail) 90 West Street.

CHAPMAN, J. L. (M) designer, Midwest Engine Co., *Indianapolis,* (mail) 1814 Brookside Avenue.

CLARK, ELMER A. (A) manager Detroit branch, Rex Machine Co., Chicago, (mail) 870 Woodward Avenue, *Detroit.*

CLERKE, JOHN W. (A) road tester, Brewster & Co., Long Island City, N. Y., (mail) Palatina Avenue, *Hollis, N. Y.*

COX, M. HOWARD (A) manager, Detroit office, Fafnir Bearing Co., New Britain, Conn., (mail) 752 David Whitney Building, *Detroit.*

DAVIS, WINSOR R. (M) member of board of directors and publicity manager, Packard Engineering Co., Inc., 1824 Euclid Avenue, *Cleveland.*

FISHER, R. B. (A) general sales manager, Buda Co., *Harvey, Ill.*

FURUSAWA, TAKESHI (M) designing engineer, Buick Motor Co., *Flint, Mich.,* (mail) 2108 Cummings Avenue.

GILBERT, ALBERT H. (M) chief engineer, tractor department, Rock Island Plow Corporation, *Rock Island, Ill.*

GRINER, OTIS EDWARD (M) sales and service engineer, Midwest Engine Co., *Indianapolis.*

HARROD, VAUGHN C. (J) draftsman, Kelly-Springfield Motor Truck Co., *Springfield, Ohio,* (mail) 316 Catherine Street.

HAVENS, FRANCIS H. (J) draftsman and designer, Fairbanks-Morse Co., *Three Rivers, Mich.,* (mail) 705 Eighth Street.

HOSHIKE ISAMU (F M) chief engineer, Tokyo Gas & Electric Engineering Co., *Otemachi, Tokyo, Japan,* (mail) 124 Funudo Iriarai Ebaragun.

JOHNSON, JOHN O. (M) chief of gage section, Ordnance Department, *Washington,* (mail) 831 Rittenhouse Street, Northwest.

JOSSELYN, H. E. (A) sales engineer, Modine Mfg. Co., *Racine, Wis.*

KARGAU, THEODORE (M) production engineer, Bartholomew Co., *Peoria, Ill.*

KEITH, HERBERT A. (M) general manager, Bowen Products Corporation, 882 East Seventy-second Street, *Cleveland.*

KRAMLICH, GEORGE VALENTINE (J) draftsman, Bethlehem Motors Corporation, *Allentown, Pa.,* (mail) 230 North St. Cloud Street.

LEWIS, FRANK M. (J) Webb Academy, *New York City,* (mail) 2201 University Avenue.

LOHMAN, RALPH W. (M) agricultural engineer, 39 Cortland Street, *New York City.*

LONG, ALBERT R. (A) consulting engineer, Sure Spark Ignition Co., *Washington,* (mail) c/o J. W. Dissette, Congress Hall Hotel.

MILLER, THEODORE C. (A) branch manager, American Bosch Magneto Corporation, 223 West Forty-sixth Street, *New York City.*

MORGAN, D. (M) engineer, Lincoln Motors Co., *Detroit,* (mail) 128 Peterboro Avenue.

NEIDHART, H. H. (J) layout draftsman, Service Motor Truck Co., *Wabash, Ind.*

NIEHOFF, PAUL G. (A) president and general manager, Paul G. Niehoff & Co., Inc., 232 East Ohio Street, *Chicago.*

PACKARD, WARREN (A) Packard Engineering Co., 1824 Euclid Avenue, *Cleveland.*

PHILLIPSON, BRAINERD F. (M) president, Climax Molybdenum Co., 61 Broadway, *New York City.*

PORTAGE RUBBER CO. (Aff) *Akron, Ohio.* Representative: J. T. Johnson, works manager.

REDHEAD, J. H. (A) assistant sales manager, National Malleable Castings Co., *Cleveland.*

RICHARDSON, F. E. (M) 143 Bellevue Apartments, *Dayton, Ohio.*

ROBOTTI, ITALO (F M) FIAT Co., *Turin, Italy.*

RUGG, HARRY MELVIN (A) supervisor of technical instruction, International Committee, Y. M. C. A., 347 Madison Avenue, *New York City.*

RUSSELL, CHARLES E. (M) mechanical engineer, Dayton Wright Co., Division of General Motors Corporation, *Dayton, Ohio,* (mail) 232 K Street.

SALTZMAN, HERBERT S. (J) designing engineer, ordnance engineering department, Holt Mfg. Co., *Peoria, Ill.,* (mail) 603 Hamilton Boulevard.

SHINN, LORABEE C. (J) mechanical draftsman, Indiana Truck Corporation, *Marion, Ind.,* (mail) 700 West Fifth Street.

SHIVERS, PAUL F. (M) electrical and mechanical engineer, Automatic Light Co., Inc., *Ludington, Mich.,* (mail) 324 North Charles Street.

SHOGRAN, IVAR L. (J) aeronautical draftsman, Packard Motor Car Co., *Detroit,* (mail) 412 Wabash Avenue.

SLATER, EMMETT J. (M) chief engineer, Clay Engine Mfg. Co., *Cleveland.*

STEELE, M. J. (M) chief draftsman, Packard Motor Car Co., *Detroit,* (mail) 1117 Seminole Avenue.

STEUART, JAMES L. (A) lawyer, Steuart & Perry, 60 Wall Street, *New York City.*

SWIGERT, W. K. (M) vice-president and general factory manager, Oakes Co., *Indianapolis.*

THOMAS, J. B. (M) chief inspector, Westinghouse Electric & Mfg. Co., *Lester, Pa.*

THURSTON, ARTHUR L. (M) assistant chief aeronautical engineer, Curtiss Aeroplane & Motor Corporation, Garden City, N. Y., (mail) 66 Hardenbrook Avenue, *Jamaica, N. Y.*

TOLEDO STANDARD COMMUTATOR CO. (Aff) 534 Spitzer Building, 2242 Smead Avenue, *Toledo.* Representative: Eugene Rheinfrank, vice-president.

TWELVETREES, RICHARD W. R. (F M) technical manager and chief engineer, British Motor Cab Co., Ltd., London, (mail) 195 Bedford Hill, *London S. W., 12, England.*

VAN KEUREN, H. L. (M) mechanical engineer, 1706 Commonwealth Avenue, *Boston.*

WARNER, JOSEPH R. (M) chief draftsman, Dyneto Electric Co., *Syracuse, N. Y.,* (mail) 515 Boyden Street.

WATRY, JOHN T. (M) assistant to superintendent, Werra Aluminum Foundry Co., *Waukesha, Wis.,* (mail) 211 Hartwell Avenue.

WELLER, JOSEPH F. (M) president, Kellogg Mfg. Co., *Rochester, N. Y.*

WHITNEY, C. PAUL (M) superintendent of instruction, American Automotive School Association, Main and Haskell Streets, *Dallas, Tex.*

WILLARD, DONALD E. (M) president and treasurer, Decatur Malleable Iron Co., *Decatur, Ill.*

ZIESENHEIM, FRED C. (M) experimental engineer, tractor works, International Harvester Co., *Chicago,* (mail) 3210 Arthington Avenue.

Applicants *for* Membership

The applications for membership received between March 18 and April 10, 1920, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

AFFLECK, BERTRAM L., general manager of service, Packard Motor Car Co. of Boston, *Boston.*

ARMSTRONG, J. FRED, secretary, Sheldon Axle & Spring Co., *Wilkes-Barre, Pa.*

BASTER, FOREST S., checker and designer, Grant Motor Car Corporation, *Cleveland.*

BIACHARD, E. R., service manager, Republic Motor Car Co., 520 Yonge Street, *Toronto, Ont., Canada.*

BINDING, JOHN, draftsman, Dayton Stamping & Tool Co., *Dayton, Ohio.*

BUTLER, ARTHUR G., mechanical draftsman, Curtiss Aeroplane & Motor Corporation, *Garden City, N. Y.*

CHAMBERS, J. L., student, University of Toronto, *Toronto, Ont., Canada.*

CLIFFORD, ANDERSON DUNHAM, district manager, B. F. Goodrich Rubber Co., *Akron, Ohio.*

CORMIER, ANDREW L., time study, Arvac Mfg. Co., *Anderson, Ind.*

DAVIS, ROBERT W., mechanical designer, A. B. Cosgrove Co., 1476 Broadway, *New York City.*

DEAN, D. MERLIN, tester, Hudson Motor Co. of Illinois, 1126 South Wabash Avenue, *Chicago.*

DEBRUN, FRANK H., mechanical engineer, Mudge & Co., Railway Exchange Building, *Chicago.*

DONALDSON, O. M., district manager, 521 Guardian Building, *Cleveland.*

DOWNS, CYRIL WINFRED, inspector of machined gasoline engine parts, Pittsburgh Model Engine Co., *Pittsburgh.*

DUNN, WILLIAM C., chief engineer, H. J. Walker Co., *Cleveland.*

FAIRCHILD, SHERMAN M., president, Fairchild Aerial Camera Corporation, *New York City.*

FISHER, HERBERT G. M., foreman, Pierce-Arrow Motor Car Co., *Buffalo.*

FLING, W. F., chief engineer, Hayes Wheel Co., *Jackson, Mich.*

FORSBERG, UNO, vice-president, S. K. F. Administrative Co., 5 Nassau Street, *New York City.*

FRANCK, JOHN P., sales manager, Guide Motor Lamp Mfg. Co., West 115th Street and Madison Avenue, *Cleveland.*

FRASER, HARRY, engineering department, Oakland Motor Car Co., *Pontiac, Mich.*

GALLEY, CHARLES E., student, Michigan State Auto School, *Detroit.*

GARGIULO, FREDERICK, president and treasurer, G & O Mfg. Co., 598 State Street, *New Haven, Conn.*

GEORG, JOSEPH C., engineer, J. B. Norton Co., Inc., *Utica, N. Y.*

HEITZMAN, H. L., assistant secretary, Fedders Mfg. Co., Inc., 57 Tonawanda Street, *Buffalo.*

HIPPEE, H. P., engineer, Hippee States Co., *Des Moines, Iowa.*

HOMMEL, C. L., chief inspector, Henry Ford & Son, Inc., *Dearborn, Mich.*

INNES, J. W., chief inspector, Gray-Dort Motor Co., *Chatham, Ont., Canada.*

JOHNSON, FRANK E. H., chief engineer, Wolseley Motors, Ltd., 81 Avenue Road, *Toronto, Ont., Canada.*

JULSRUD, ROLF S., mechanical draftsman, Shaw-Enochs Tractor Co., 2416 University Avenue, Southeast, *Minneapolis.*

LARGE, FRANK EARL, second vice-president in charge of engineering, Johnson Rim & Parts Co., Inc., 2519 Delaware Avenue, *Buffalo.*

MCGLASHAN, JAMES, chief engineer, Martin Parry Corporation, *York, Pa.*

NICKELSEN, J. M., engineer, Buick Motor Co., *Flint, Mich.*

PARKER, JESS, chief inspector, Jordan Motor Car Co., East 152nd Street, *Cleveland.*

PEARCE, FREDERICK, checker and assistant chief draftsman, Packard Motor Car Co., *Detroit.*

PICKETT, E. V., sales manager, Bissinger Magneto Co., *Cleveland.*

RAPIN, EDWARD A., layout draftsman, Oakland Motor Car Co., *Pontiac, Mich.*

SAYRE, GORDON B., designer, Packard Motor Car Co., *Detroit.*

STOCKWELL, JOHN I., transportation engineer, Ludlum Motor Car Co., 369 Halsey Street, *Newark, N. J.*

THEISINGER, EARL F., mechanical draftsman, Class Journal Publishing Co., 239 West Thirty-ninth Street, *New York City.*

TUBBS, FRED L., vice-president, Alamo Farm Light Co., 703 Tower Building, *Chicago.*

VOLZ, GEORGE REX, editorial representative, *Motor Age*, Mallers Building, Madison Street and Wabash Avenue, *Chicago.*

VOSLER, KENNETH D., aeronautical draftsman, Aeromarine Plane & Motor Co., *Keyport, N. J.*

WALLACE, WILLIAM H., sales engineer, Standard Parts Co., *Cleveland.*

WALLACE, WILLIAM M., chief draftsman, Bureau of Construction and Repair, Navy Department, *Washington.*

WARNER, GEORGE C., sales engineer, Gurney Ball Bearings Co., *Jamestown, N. Y.*

WEBB, W. L., engineer, Crossley Brothers, Ltd., *Openshaw, Manchester, England.*

WESTLING, CARL J., draftsman, Dayton Stamping & Tool Co., *Dayton, Ohio.*

WHITACRE, WALTER, chief draftsman, Arvac Mfg. Co., *Anderson, Ind.*

WILSON, ROBERT W., experimental engineer, Timken-Detroit Axle Co., Clark Avenue, *Detroit.*